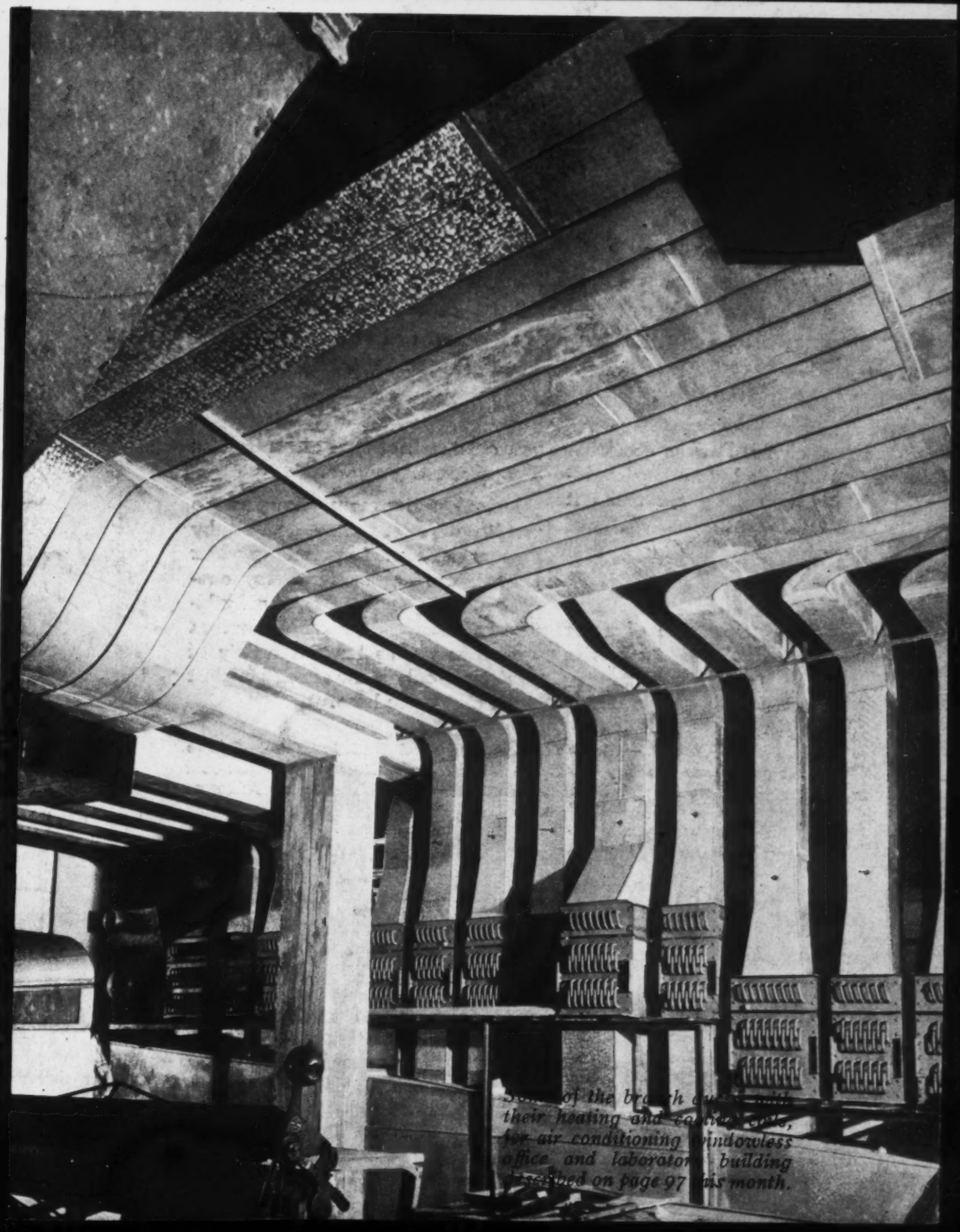
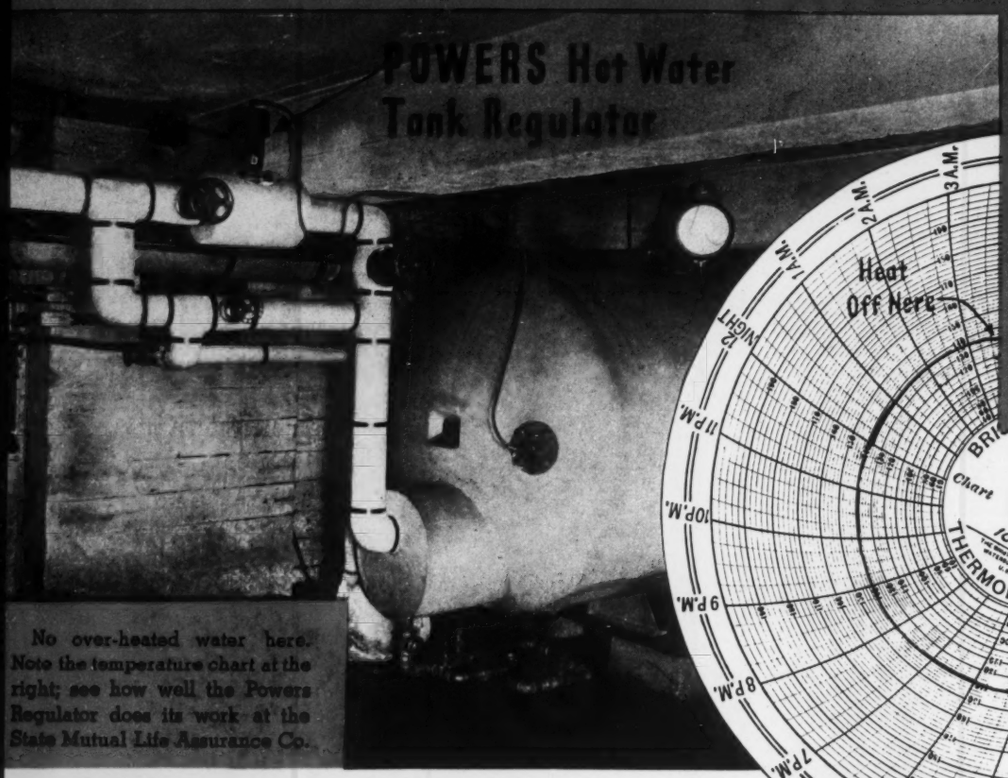
Heating · Piping and Air Conditioning

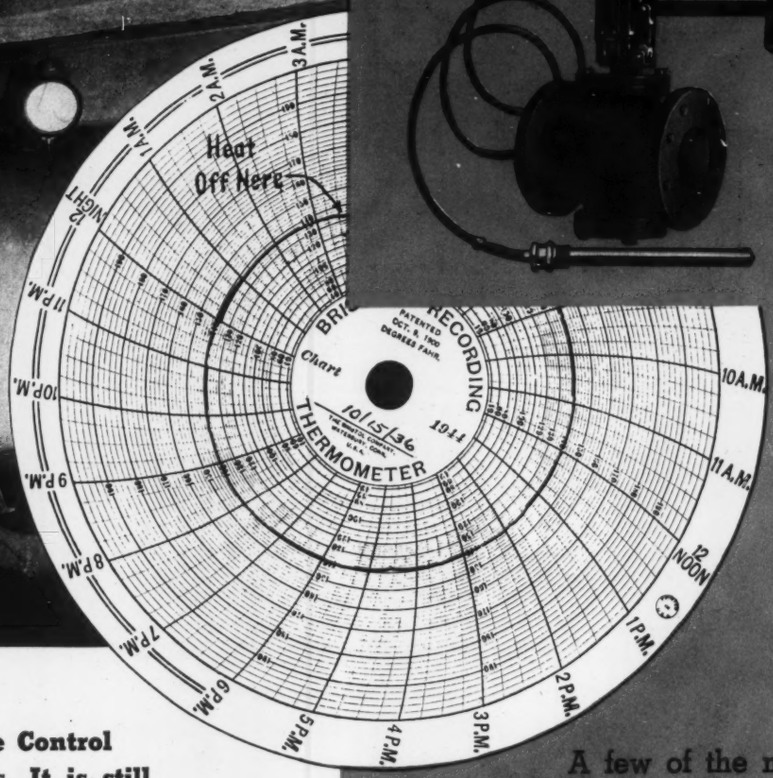


Some of the branch offices have their heating and cooling units for air conditioning windowless office and laboratory building described on page 97 this month.

Installed in 1916—*still giving Accurate control*



No over-heated water here. Note the temperature chart at the right; see how well the Powers Regulator does its work at the State Mutual Life Assurance Co.



"We have been using Powers Temperature Control on our hot water tank for the past 20 years. It is still working perfectly and has never been off the line." . . . writes Mr. H. C. Thurston, Chief Engineer of the STATE MUTUAL LIFE ASSURANCE CO. of Worcester, Mass.

The first cost of Powers control is sometimes higher but its greater dependability and long life make it cheapest in the end.

•

Engineering Service—Whenever you have a problem of water temperature control call in a Powers engineer. His recommendations may save you considerable time and help you get the best type of control for any particular purpose.

No other firm can offer you the wealth of experience gained by Powers engineers in providing water temperature control for every conceivable purpose in all types of buildings and industries, and no other firm can offer you so large a variety of controls—only a few of our simplest types are shown here.

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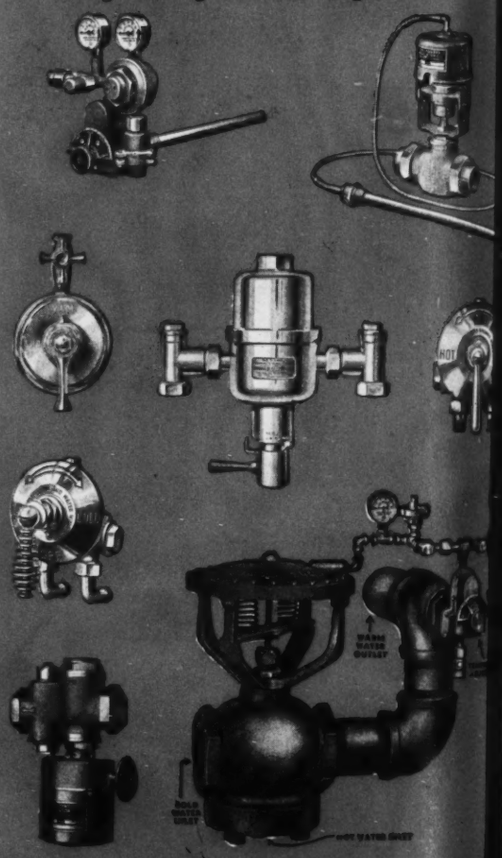
POWERS

A few of the many types of Powers control for regulating water temperatures



THE MOST COMPLETE LINE OF REGULATORS MADE FOR . . .

WATER TEMPERATURE CONTROL

THE EDITOR'S PAGE

■ **Sessions** on air conditioning for health and in the treatment of disease, and on acoustics in air conditioning and ventilating work, featured the American Society of Heating and Ventilating Engineers' annual meeting in St. Louis last month, the proceedings of which are to be published in the Journal Section of the A.S.H.V.E. in our next issue. . . . Among the unannounced events on the meeting program was an address by Capt. Richard Reiss of the London County Council Housing Authority, who described the work being done in England on clearance of slum areas and low cost housing of low income groups. Some 60,000 units have been constructed in England since the World War, said Capt. Reiss. . . . An address by Prof. G. L. Larson, retiring president of the A.S.H.V.E., at the annual banquet, was broadcast over a 27 station network. Prof. Larson was introduced to the radio audience by Bennett Chapple, "Ironmaster" of the Armco program, Armco devoting part of its radio time to the A.S.H.V.E. as it did last year. . . . Dr. Arthur C. Willard, president of the University of Illinois, was the principal speaker of the evening.

■ **The first issue** of "Air Conditioning Trends," devoted to reporting news from the sales side of air conditioning, was mailed last month from "Air Conditioning Headquarters," the Keeney Publishing Co., publishers of HEATING, PIPING AND AIR CONDITIONING and "American Artisan." . . . Up-to-the-minute, "Trends" devoted its first number to the public utility's place in the air conditioning picture, and effective cooperation of the manufacturer, the engineer and the contractor with the public service company in promoting the sound growth and wise development of the industry. . . . Featured was an interview with George E. Whitwell, vice-president in charge of sales of Philadelphia Electric Co., whose co-operative promotion plan that helped to stabilize air conditioning sales was described in another article. An analysis of data from an Edison Electric Institute report, a preview of A.S.H.V.E. research, and an article on forced air heating and residential air conditioning were included.

■ **Marshall Field and Co.**, Chicago, is to spend over a million dollars this year in air conditioning and modernizing its loop and Oak Park stores, President Frederick D. Corley announced last month. . . . Air conditioning is to be installed for the basement and first floor of both the State and Wabash stores, as well as the store for men, and for the entire Oak Park unit. . . . According to Mr. Corley, air conditioning of Field's Evanston store is only a matter of time. . . . One of the problems to be solved in the design of the air conditioning system is caused by the two "wells" in the State street store, one of which extends to the top of the building and the other of which goes up six floors.

■ **"Talks"** is the title of a pamphlet just published reporting the addresses made by the principal speakers at the Westinghouse air conditioning distributors' meeting in December. H. W. Reding of Danforth Co., Pittsburgh, spoke on "Organized for Business"; Benjamin Natkin of Natkin and Co., Kansas City, on "How We Closed the Toughest Job This Year"; A. C. Buensod of Buensod-Stacey Air Conditioning, Inc., New York City, on "What It Takes to Sell the Large Buyer," and Arnold Goelz, Kroeschell Engineering Co., Chicago, on "The Difference Between Profit and Loss in the Air Conditioning Distributors' Business." . . . The importance of engineering in air conditioning was stressed by several of the speakers. Mr. Reding stated there is little doubt that a general air conditioning business is an engineering business, and that an organization must consist of engineers, with additional specialized talents for designing, selling, installing, servicing and management. Mr. Goelz stressed the necessity of making very complete detailed drawings so that a system will be installed correctly and without loss of time; such drawings are the most effective means of keeping down the cost of installation and insuring proper results, he said.

■ **Gross business** transacted by the Federal Housing Administration up to January 1, 1937, totaled $1,350,157,149, according to Stewart McDonald, Federal Housing Administrator. This included mortgages selected for appraisal, commitments to insure large scale housing projects and modernization and repair notes insured. . . . Approximately $810,000,000 of this was transacted during the year 1936. . . . Mortgages on large scale housing projects approved up to January 1 amounted to $41,141,000.

■ **An outstanding feature** of the year's air conditioning statistics for Chicago was the amount of horsepower contracted for in December. Contrary to the usual winter slump, December represented the third highest monthly total for the year, sixteen new plants being installed or contracted for, with a capacity of 1044 tons or 1205 hp. This was an increase of 78 per cent in number and 560 per cent in capacity over December, 1935. . . . Air conditioning has "definitely arrived" as one of the world's leading industries, said L. R. Boulware of Carrier Corp. at a special meeting of Carrier engineers at Newark last month, which was called for reorganization necessary because of increased business, both in large and small installations. . . . At the A.S.R.E. meeting in New York in December, Mr. Boulware pointed out that "the engineer has a far greater degree of activity in sales work in the air-conditioning business than in any other that I have known anything about before. The engineer is inseparably connected with the sale, rather than just designing and building a product which he hands to some salesman."

■ **Alex Dow**, president of The Detroit Edison Co., was awarded the American Institute of Electrical Engineers Edison Medal for 1936, "for outstanding leadership in the development of the central station industry and its service to the public." . . . T. A. Marsh, Iron Fireman Mfg. Co., has been elected chairman of the executive committee of the fuels division of the American Society of Mechanical Engineers. . . . A symposium on corrosion testing and one on lubricants are to be features of the American Society for Testing Materials' regional meeting at the Palmer House, Chicago, March 2 and 3. Some 100 meetings of Society committees will be held during the week. . . . The National Oil Burner and Air Conditioning Exposition to be held in Philadelphia March 15-19 is expected to be the largest and most representative in the history of the industry, according to G. Harvey Porter, managing director of the Oil Burner Institute.

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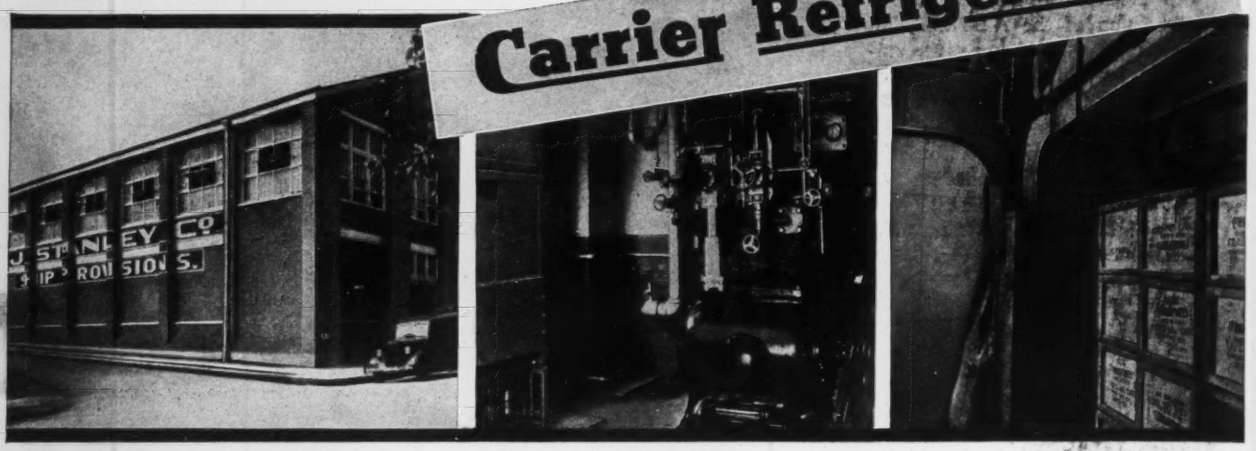

1 No Landlubbers, J. Stanley Company supply meats and provisions for liners. To keep meats in frozen condition, Mr. Stanley selected Carrier Refrigeration for modern Bayonne, N. J. plant, reports after one year's use: "I would unquestionably select your company were I to duplicate the job."

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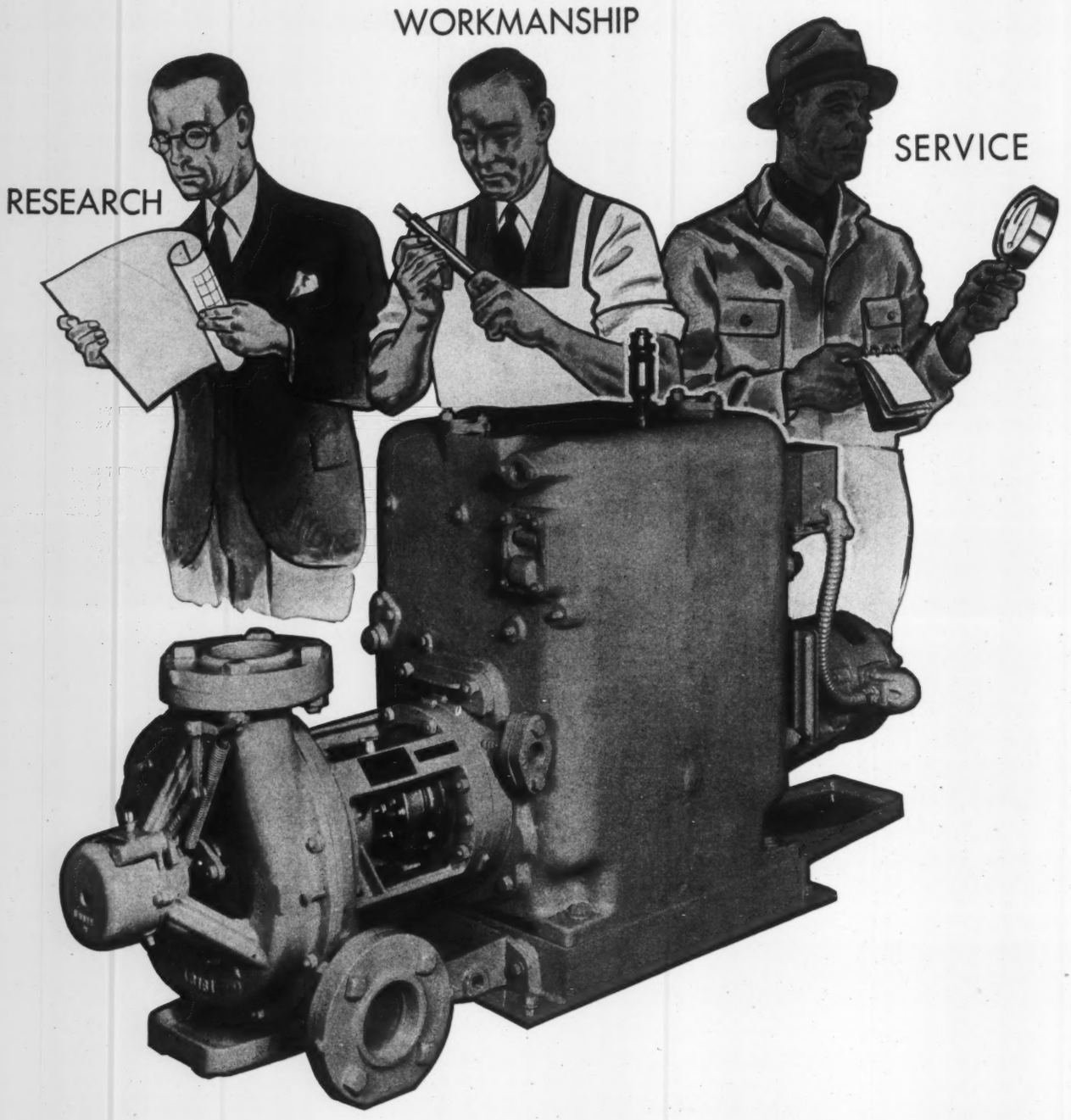

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Heating · Piping and Air Conditioning

Vol. 9, No. 2 • *February, 1937*

Heating System Control Methods for Reducing Fuel Consumption

By Kalman Steiner*

IN previous issues, the author and Paul R. Unger have discussed efficient combustion and efficient fire control.[1] It has been pointed out that effective use of modern methods of combustion control results in low cost of steam generation. But in the heating of large buildings, another factor—efficient steam utilization—is equally as important as efficient steam generation. It is our purpose this month to review the means and methods available for heating buildings with minimum steam consumption.

Heating plants are designed for the most severe weather condition generally prevailing in any particular locality, and are sized to heat a building to 70 F when the outdoor temperature is at the lowest assumed for design purposes. In most regions this lowest temperature exists less than 5 per cent of the heating season, so that even during the daytime the heating system is not called upon for its maximum output during about 95 per cent of the season. In addition, most buildings do not require 70 F inside temperature at night, so that here again the load condition is considerably less than the plant's capacity. It therefore becomes necessary to control the heating plant output; this can be accomplished manually or automatically, and it can be based upon direct fire control or principally upon control of the heating system itself.

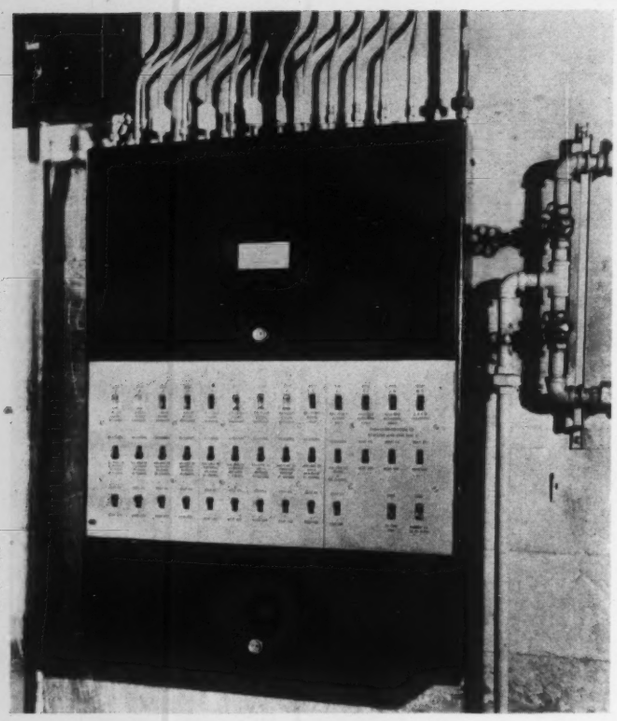
In many medium sized buildings, such as apartments and small hotels, the firing device—either oil burner, stoker, or gas burner—can be and is operated directly from a room thermostat placed in a position representing as closely as possible an average temperature condition for the entire building. This results in intermittent operation of the burner, and if the heating system is in fair condition and the steam circulation is good, the control will be fair (that is, as satisfactory as the thermostat location is truly average for the building), and fuel consumption will be kept within reasonable limits. This method, however, has the objectionable features that it is difficult to select a point of average temperature for the thermostat location; that the building temperature may vary over a fairly wide range between cycles of burner operation; and that the occupants of the room selected for the thermostat location may, consciously or unconsciously, affect the heating of the entire building.

If the thermostat be omitted entirely, and the burner be placed under control of a pressure switch, then the boiler pressure will be maintained between the upper and lower limits of this switch. This method will assure a continuous supply of steam to the radiation, but the only way that the building occupants can regulate room temperature is by opening and closing the radiator valves or windows. This is decidedly an uncertain method of

In general, a heating plant operates at some point below its maximum capacity 95 per cent of the time, which means that control is essential to economy. Efficient control methods of several types are available, and it is the author's purpose to describe them and review their features, as well as to discuss reducing fuel waste by the proper control and the correct operation and maintenance of plant and building heating systems. His article is particularly valuable in the concise explanation of the various heat control methods which is included

*Ace Engineering Co., Chicago, Ill. Copyright, 1937, by Kalman Steiner.

[1] "How to Operate Oil Fired Heating Plants Efficiently," by Paul R. Unger and Kalman Steiner, HEATING, PIPING AND AIR CONDITIONING, May, 1936, pp. 255-258. "The Combustion Process and Boiler Efficiency," by Paul R. Unger and Kalman Steiner, HEATING, PIPING AND AIR CONDITIONING, July, 1936, pp. 361-364. "Combustion Control for Oil Fired Boiler Plants," by Kalman Steiner and Paul R. Unger, HEATING, PIPING AND AIR CONDITIONING, October, 1936, pp. 544-547.



Control panel in office building for zone control system of direct radiation through electro-pneumatic pilot valves

regulation, and the resultant fuel consumption is usually high. A similar method is to place the burner, if either gas or oil, under modulating or high-low control, so that the fire size or fuel firing rate is proportioned to boiler pressure. Both these methods are extensively used in small and medium sized buildings, but as a rule are wasteful of fuel.

The fuel burner can be relieved of direct responsibility for co-ordinating its operation to steam requirements by placing the steam admission to the piping system under the control of a main steam valve. Then the burner has only to maintain a head of steam, so that at any time that the main steam valve opens, steam will be available. In this way the operation of the main control valve indirectly controls the fuel firing device, for as soon as the valve either stops or restricts the steam flow into the piping system, the burner begins building up steam pressure in the boiler, and the boiler pressure control either cuts off or diminishes the fire correspondingly. There are a number of commercial forms of apparatus for effecting the operation of such steam valves; although some of these are adaptable only to steam valve control, most of them can be connected directly to the burner and accordingly regulate steam valve or burner independently or simultaneously.

The several methods for controlling the supply of steam to the heating system differ considerably. In one system the main steam valve is operated by a control device actuated by outdoor temperature. The lower the outdoor temperature, the shorter the interval between successive openings of the valve. Also, the valve will remain open for a greater time when it does open.

In another system, a control device installed on the roof of the building is heated electrically at frequent intervals. This control device is so designed that the rate at which it loses heat when the current is off will match the rate at which the building loses heat. In this way the time required for the control device to cool, when the heating current is off, determines the admission of steam to the heating system.

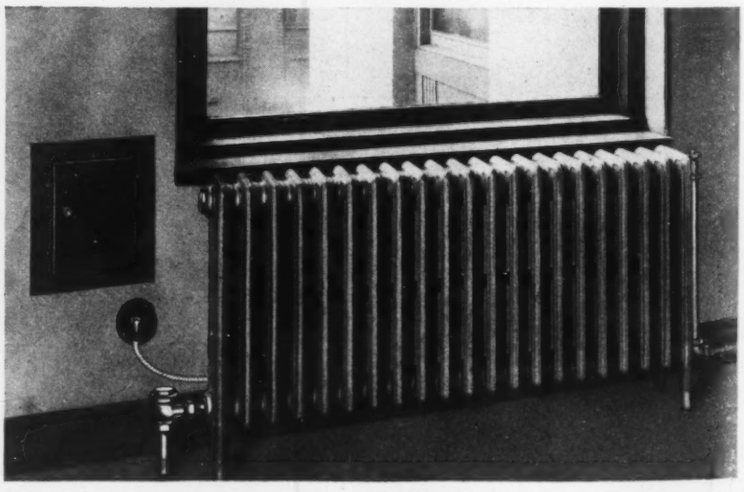
A third system uses a number of thermostats in representative locations throughout the building, and the readings of all of them are averaged electrically. This average temperature of the building then automatically operates the main valve controlling the steam supply to the heating system.

It must be borne in mind that there are many factors in addition to outdoor temperature that influence the rate of heat loss from a building; among them are wind direction and velocity, and solar radiation. There are also many factors other than outside temperature that influence the rate at which heat must be supplied to a building, among them being relative humidity, individual opinions as to comfortable temperature, percentage of occupancy, hours of building tenancy, ventilation or air changes within the building, etc. Moreover, all types of controls are not alike in their reactions to the different factors; some will compensate more effectively for certain factors than will others. Hence, it is obvious that building temperature control is a complex subject.

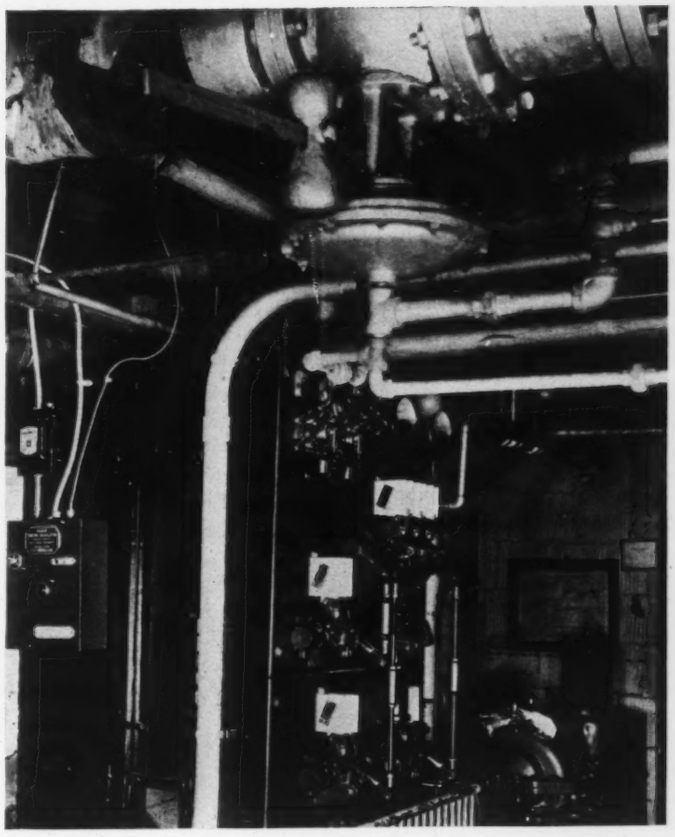
Various Types of Control Systems

The following is a review of some commercial types of control equipment with an analysis of their operating features.

Method No. 1—This method balances outside temperature against radiator temperature, roughly in a manner that will result in a 2 deg temperature increase above 70 F in the radiator for each 1 deg temperature drop below 70 F outdoors. The instrument consists essen-



Method of recessing control instrument into wall box, with bulb attached to "last" radiator. Instrument also has outdoor bulb



Regulator having outdoor bulb, controlling operation of main steam valve through pilot valve

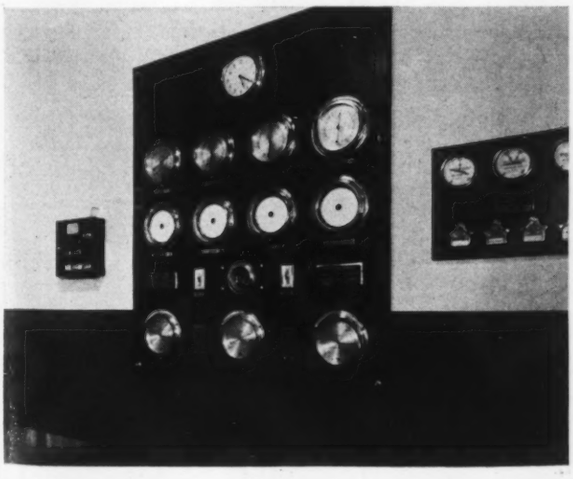
tially of a bourdon tube which actuates a mercury tube for electrical switching. Two fluid containing bulbs are connected by fine tubing to the bourdon tube. One bulb is placed outdoors; the other is clamped to the control radiator in such manner that it registers or responds to the average temperature of the entire radiator. As the outside bulb cools its fluid contracts, causing the bourdon tube to alter its shape and consequently to tilt the mercury tube into the position that will close an electrical circuit for opening the main steam valve, or start the oil or gas burner or coal stoker, as the case may be. As soon as steam reaches the radiator the fluid in the radiator bulb begins to expand; when the expansion in this bulb is equal to the contraction in the outdoor bulb the bourdon tube will again assume its normal position, and the electrical circuit will either be opened or reversed, depending on the control wiring. In either case the steam supply to the radiator will be shut off.

The relation between the rise in radiator temperature and the drop in outdoor temperature depends upon the relative sizes of the outdoor and radiator bulbs. For steam systems, the radiator bulb is made twice as long as the outdoor bulb, and this relation will cause the instrument to raise the radiator temperature 2 deg for each 1 deg that the outdoor temperature drops. If a building is to be equally heated throughout, it is important that the distribution of steam to all the radiators be rapid and uniform; in other words, the first and last radiators should receive steam at approximately the same time. To accomplish this it frequently is necessary to install orifices in the steam supply connection to all of the radiators. (Orificing will be discussed in some detail later.)

In addition to the "on and off" type, this method can also be supplied in a modifying or throttling type, whereby the steam control valve is made to assume such a position that steam is supplied constantly and in such quantity that the radiator temperature is held steadily at the point set by the outdoor bulb at any time.

Method No. 2—This method regulates the heating of a building solely from the outside temperature, operating the burner or steam valve intermittently. The frequency and length of the operating periods depend upon the outdoor temperature. This instrument is based upon the assumption that the heating plant should operate continuously when the outdoor temperature is as low as the base temperature assumed for design and, furthermore, that when the outdoor temperature is higher than this design minimum, the heating system should operate for a correspondingly shorter time. In addition to varying the period and frequency of operation of the firing equipment or the main steam valve, this method also varies the time at which the heating system is turned on in the morning and shut off at night—the colder the weather the earlier the start and the later the shut off.

The expansion or contraction of the fluid in the outside bulb causes the selection of the proper path of contact of a contact point upon the surface of a rotating disc, which disc has metallic embossments upon it to complete an electrical circuit whenever the contact point is in a position touching them. The resultant circuit energizes a relay, from which proper switching is provided to control the firing mechanism. The program as well as the frequency of operation may be varied to suit the characteristics of the heating system.



Control panels and instruments in engineer's office of city hall and court house building. In center panel, indicating gages and thermometers showing pressures and temperatures at various points. At left, control instrument balancing "on" periods for direct radiation against outside temperature. At the right are seen the manual control instruments governing the ventilating system

Method No. 3—This control method consists primarily of a hollow mass of iron inside of which is an electrical heating element and a thermostat; it is installed on the roof. The electrical element heats the iron intermittently under control of the thermostat. The rate at which the mass of iron cools depends upon the outdoor temperature, wind velocity, etc.; the faster it cools, the greater the frequency with which the heating element is turned on and the greater the length of time that will be needed to heat the iron when the heating element is turned on.

The control wiring comprises two parallel electrical circuits. When the thermostat inside the mass of iron calls for heat, one circuit turns on the heating element in the iron and the other opens the main steam valve to the building heating system or starts the boiler firing device. When the thermostat inside the mass of iron is satisfied, both the electrical heating circuit and the circuit to the steam valve are opened. In this way the operation of the building heating system parallels the operation of the heater in the mass of iron on the roof. The satisfactory operation of this system depends upon how successfully the rate of heat loss from the iron follows the rate of heat loss from the building as a whole.

Method No. 4—It is the intent of this system to secure a balance between the outside temperature and the periods during which steam is supplied to a building by balancing three temperatures: outdoor, boiler water, and condensate return. (The boiler water temperature is of course used as an index of steam pressure.) The three temperature registering elements are thermocouples in which minute electrical currents are induced just as in a millivoltmeter pyrometer. All three currents are conducted to a master control box where they are magnified many hundreds of times by means of electronic tubes. In the control box a sort of Wheatstone bridge balances these three currents into equilibrium.

When the outdoor temperature is 65 F and the return pipe is at room temperature, the boiler water is maintained just below the boiling point, which would be around 210 F in an atmospheric heating system or some lower temperature in a vacuum system. The boiler water element circuit is previously set for whatever has been determined upon as the lowest boiler pressure to be considered as minimum. When the outdoor temperature falls, the electrical balance in the master control is upset, and a relay is caused to start the firing. Immediately, a head of steam is produced (the steam pressure developed being influenced by the outdoor temperature) and is sustained until condensate reaches the farthest point in the return piping and affects the return temperature element. The firing is then interrupted in accordance with that return temperature, or in other words the maintained boiler water temperature is reduced by an amount indicated by the temperature of the return water at the farthest point from the boiler. The result is that in a vacuum system the differential and therefore steam circulation is regulated in accordance with outdoor temperature.

The distinctive feature of this system is that the settings of the three device elements are balanced against each other in an empirical manner, gauged solely by the characteristics of the particular heating system. Full flexibility is provided so that adequate adjustment of each factor may be made with accuracy, as may be dictated by the nature and peculiarities of the heating plant.

This control method can also be applied to regulate a main steam valve as well as a stoker or burner. The switch governing change to night control is manually operated, so that an attendant can throw the control from day temperature to night temperature and the reverse at any time desired. A time clock may be used for the same purpose.

It is perhaps worth noting that of these four control methods, the second and third are based upon the assumption that the rate of steam generation will be constant during every moment that heat is being called for. The others, on the contrary, do not anticipate a rate of steam generation.

[*Steam control systems that operate exclusively upon the heating system will be described in a second article, and radiator orificing, correction of piping defects, fuel consumption estimates, and economies and savings that can be effected in the operation of heating systems will be discussed.*]

Silicosis and Allied Disorders

A six-point program for protecting the health of industrial workers, and a definite plan of medical research designed to help curb industrial disease, is recommended to the *Air Hygiene Foundation* by its medical committee in a report on "Silicosis and Allied Disorders." The committee has attempted to bring together a practical summary of what is known and what remains to be learned about dust disease.

The report outlines the following program of health control for the guidance of employers:

A practical program of pre-employment examination of all workers exposed to dust containing silica is essential. Such examinations should include a complete physical examination of each individual, a careful history of past occupational exposure to dust, and a chest roentgenogram (x-ray.)

The value of such procedure may be summarized thus:

1. Protection of prospective employees, who may have diseased lungs, from silica exposure.

2. Discovery of hazardous jobs, as a result of finding the silicosis cases, in order to eradicate these hazards.

3. Discovery of active and open cases of tuberculosis which are in contact with other employees, especially protecting the younger workers who are susceptible to contact infection.

4. Discovery, through periodic examination of those with inactive tuberculosis, of any reactivation of their tuberculosis, so as to protect especially the younger employees. This also offers the infected individual a better chance of cure.

5. Discovery of early cases of silicosis through periodic examination in order to give added protection from further excessive dust exposure.

6. Determination, through periodic physical examination, of the effectiveness of the dust control program.

In recommending projects for medical research, the report states:

There is no phase of employee health which concerns the employer more than does the question of dust diseases, and the ever increasing extent to which the employees' health is being made a responsibility of the employer demands that every available opportunity for increasing our knowledge be explored.

[*Concluded on page* 91]

How to Solve Heat Transfer Problems

Part 2—Parallel Flow

By William Goodman*

Heat transfer problems of practically every class are met in heating, piping and air conditioning work. While research is adding to our knowledge of heat transmission coefficients, there seems to be—in general—lack of knowledge of how to use such data in computing the performance of various types of equipment. . . . It is to fill the need for this information that these articles have been prepared, their object being to present simple methods for solving such problems, particularly the more troublesome ones dealing with counter-flow. . . . In Part 1 the classes of heat transfer problems were outlined, the solution of problems involving condensing or vaporizing fluids was explained, and a table compiled by the author, which simplifies computations, was presented. . . . Parallel flow is the division of the subject that is considered this month.

IN the problems given in Part 1,[1] the temperature of only one of the two fluids changed, that of the other remaining constant. From now on, we will deal with situations in which the temperature of both fluids changes, and as has been stated, when the temperature of both fluids changes it is necessary to take into account the relative directions of flow.

Fig. 5 illustrates—for parallel flow—the temperature changes which occur in both fluids as they flow past the heat transfer surface. Parallel flow is little used in actual work because it requires more surface for the same set of conditions. Nevertheless, an understanding of the solution of problems in parallel flow is of considerable aid in following the explanations of the problems involving the widely used counterflow method.

Problems in parallel flow are solved in exactly the same way as the problems of Part 1, with one exception. This exception is, for parallel flow only,

$$\mathbf{M = \frac{U\,A}{G\,s}\left(1+\frac{G\,s}{G'\,s'}\right)} \qquad [3]$$

where

U = Coefficient of heat transmission, Btu per hr per deg temp. diff. per sq ft of surface
A = Area of heat transfer, sq ft
G = Weight of warm fluid, lb per hr
s = Specific heat of warm fluid
G' = Weight of cool fluid, lb per hr
s' = Specific heat of cool fluid
(See Table 1 for M.)

Example 7 (Classes 1 and 5): An air supply of 12,000 cfm is to be heated from 60 to 110 deg, in a parallel flow heater, with water at an initial temperature of 180 deg. The final temperature of the water is to be 150 deg. The value of U for the heater is 14 Btu. Find (a) the area of heat transfer surface required. (b) the quantity of water which must be circulated.

Solution:

(a) It is evident from Fig. 5 that in parallel flow the large temperature difference is equal to the difference in the initial temperatures while the small difference is equal to the difference of the final temperatures.

$$D_L = 180 - 60 = 120 \text{ deg}$$
$$D_s = 150 - 110 = 40 \text{ deg}$$

$$\frac{D_s}{D_L} = \frac{40}{120} = 0.33$$

From Table 1,

$$\frac{D_m}{D_L} = 0.604$$

$$D_m = 0.604 \times 120 = 72.5 \text{ deg}$$

Since the air is the cool fluid,

$$G'\,s' = 12{,}000 \times \frac{60}{13.3} \times 0.24 = 13{,}000$$

Heat gained by air
$= 13{,}000\ (110—60)$
$= 650{,}000$ Btu per hr

$$H = A \times U \times D_m$$

$$A = \frac{650{,}000}{14 \times 72.5}$$

$A = 640$ sq ft of surface required.

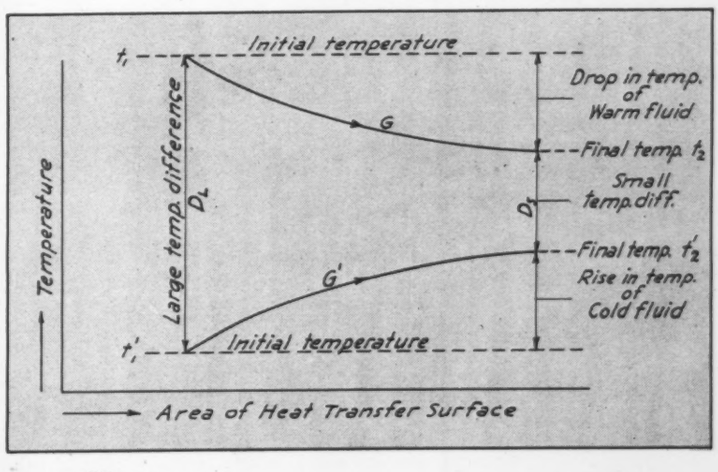
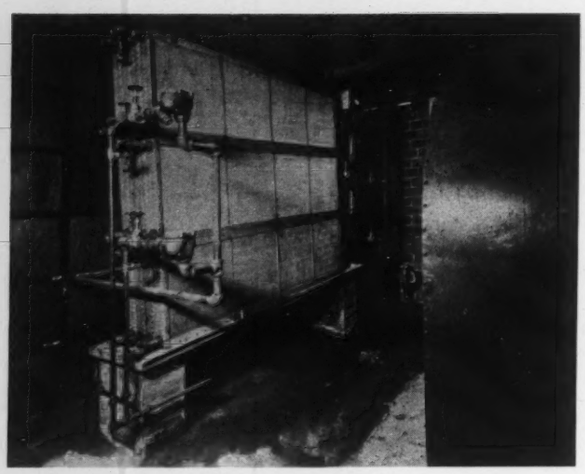


Fig. 5—Illustrating, for parallel flow, the temperature changes which occur in both fluids as they flow past the heat transfer surface. Symbols with prime marks refer to the cool fluid, and those without to the warm

*The Trane Co., La Crosse, Wis. Copyright, 1937, by William Goodman.

[1] HEATING, PIPING AND AIR CONDITIONING, January, 1937, pp. 11-14.



It is often necessary to determine the final temperature of the air leaving a blast heater such as that illustrated; the data given in these articles simplify solving the problem

Table 1—Data for Solving Heat Transfer Problems

$\frac{Ds}{DL}$	$\frac{Dm}{DL}$	$\frac{Ds}{Dm}$	M	$\frac{Ds}{DL}$	$\frac{Dm}{DL}$	$\frac{Ds}{Dm}$	M
Col. 1	Col. 2	Col. 3	Col. 4	Col. 1	Col. 2	Col. 3	Col. 4
				0.50	0.721	0.693	0.693
0.01	0.215	0.046	4.605	.51	.728	.701	.674
.02	.251	.080	3.912	.52	.734	.708	.654
.03	.277	.109	3.507	.53	.740	.716	.635
.04	.298	.135	3.219	.54	.746	.724	.616
0.05	0.317	0.158	2.996	0.55	0.753	0.731	0.598
.06	.334	.180	2.814	.56	.759	.738	.580
.07	.350	.200	2.660	.57	.765	.745	.562
.08	.364	.219	2.526	.58	.771	.752	.545
.09	.378	.238	2.408	.59	.777	.759	.528
0.10	0.391	0.256	2.303	0.60	0.783	0.767	0.511
.11	.403	.273	2.207	.61	.789	.773	.494
.12	.415	.289	2.120	.62	.795	.780	.478
.13	.427	.305	2.040	.63	.801	.786	.462
.14	.438	.320	1.966	.64	.806	.794	.447
0.15	0.448	0.335	1.898	0.65	0.813	0.800	0.431
.16	.458	.349	1.833	.66	.818	.807	.415
.17	.469	.363	1.772	.67	.823	.814	.401
.18	.478	.377	1.716	.68	.829	.820	.386
.19	.488	.390	1.660	.69	.836	.826	.371
0.20	0.497	0.402	1.609	0.70	0.840	0.833	0.357
.21	.506	.415	1.561	.71	.848	.838	.342
.22	.515	.427	1.514	.72	.852	.845	.329
.23	.524	.439	1.470	.73	.858	.851	.315
.24	.533	.451	1.427	.74	.864	.856	.301
0.25	0.541	0.462	1.386	0.75	0.870	0.862	0.287
.26	.549	.473	1.347	.76	.874	.870	.275
.27	.558	.484	1.309	.77	.879	.876	.262
.28	.566	.495	1.273	.78	.886	.881	.248
.29	.574	.506	1.238	.79	.890	.887	.236
0.30	0.582	0.516	1.204	0.80	0.896	0.893	0.223
.31	.589	.526	1.171	.81	.902	.899	.211
.32	.597	.536	1.139	.82	.907	.904	.198
.33	.604	.546	1.109	.83	.913	.910	.186
.34	.612	.556	1.079	.84	.918	.915	.174
0.35	0.619	0.565	1.050	0.85	0.923	0.921	0.163
.36	.626	.575	1.022	.86	.928	.927	.151
.37	.634	.584	.994	.87	.934	.932	.139
.38	.641	.593	.968	.88	.939	.938	.128
.39	.648	.602	.942	.89	.944	.943	.117
0.40	0.655	0.611	0.916	0.90	0.949	0.948	0.105
.41	.662	.620	.892	.91	.955	.953	.094
.42	.669	.628	.868	.92	.959	.959	.083
.43	.675	.637	.844	.93	.964	.965	.073
.44	.682	.645	.821	.94	.970	.969	.062
0.45	0.689	0.653	0.798	0.95	0.975	0.974	0.051
.46	.695	.662	.777	.96	.979	.980	.041
.47	.702	.670	.755	.97	.986	.984	.030
.48	.709	.677	.734	.98	.991	.989	.020
.49	.715	.686	.713	.99	.995	.995	.010

D_L=large temperature difference, and D_s=small temperature difference used in determining log mean temperature difference, D_m. See text for the various formulas for M.

(b) The weight of water to be circulated can be found by means of a heat balance:

$$G\,s\,(180-150) = 650{,}000$$
$$G \times 1 \times 30 = 650{,}000$$
$$G = 21{,}650 \text{ lb per hr}$$
$$Gpm = \frac{21{,}650}{60 \times 8.33} = 43.4$$

Problems such as the preceding are easily handled, and if they were the only type encountered, there would be little excuse for this article. However, a type of problem which is often encountered is that of finding the final temperature of the air leaving a given coil when only the initial temperatures of the air and water are known.

Example 8 (Classes 2 and 3): Water having an initial temperature of 55 deg is used to cool air having an initial temperature of 85 deg. A parallel flow cooling coil having an area of 900 sq ft is to be used. The value of U for the coil is 10 Btu. No condensation of moisture takes place from the air. The entire quantity of air, 8,000 cfm, is to be cooled by 45 gpm of water. Find the final temperature of the air.

Solution: Since the air is the warm fluid,

$$G\,s = 8000 \times \frac{60}{13.3} \times 0.24 = 8680$$
$$G'\,s' = 45 \times 8.33 \times 60 = 22{,}500$$
$$M = \frac{U\,A}{G\,s}\left(1 + \frac{G\,s}{G'\,s'}\right)$$
$$= \frac{10 \times 900}{8680}\left(1 + \frac{8680}{22{,}500}\right)$$
$$= 1.036 \times 1.386 = 1.436$$

Referring to Col. 4, Table 1, for $M = 1.436$, find in Col. 2,

$$\frac{D_m}{D_L} = 0.533$$
$$D_L = 85 - 55 = 30 \text{ deg}$$
$$\frac{D_m}{30} = 0.533$$
$$D_m = 0.533 \times 30 = 16 \text{ deg}$$
$$H = U \times A \times D_m$$
$$= 10 \times 900 \times 16$$
$$= 144{,}000 \text{ Btu per hr}$$

Referring to Fig. 5,

$$H = G\,s\,(t_1 - t_2)$$
$$144{,}000 = 8680\,(85 - t_2)$$
$$85 - t_2 = \frac{144{,}000}{8680} = 16.6 \text{ deg}$$
$$t_2 = 68.4 \text{ deg, final air temperature.}$$

Example 9 (Class 4): Air is to be cooled from 95 to 65 deg in a parallel flow cooler using cold water. No condensation of moisture takes place from the air. The area of the surface is 800 sq ft, and the value of U is 9 Btu. The quantity of air to be cooled is 5000 cfm. The quantity of water available is 37 gpm. The water is to be cooled by a refrigerating plant and it is desired to use water at as high a temperature as possible. Find the required initial temperature of the water.

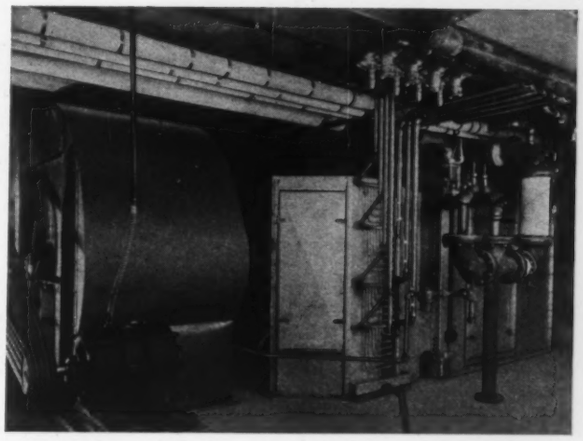
Solution: Since the air is the warm fluid,

$$G\,s = 5000 \times \frac{60}{13.3} \times 0.24 = 5420$$
$$G'\,s' = 37 \times 8.33 \times 60 = 18{,}500$$
$$M = \frac{U\,A}{G\,s}\left(1 + \frac{5420}{18{,}500}\right) = 1.33 \times 1.293 = 1.72$$

The computation of heat transfer problems may be divided into three main divisions: (1) Condensing or vaporizing. (2) Parallel flow. (3) Counterflow.

In heat transfer problems which arise in actual work, it is usually necessary to find the numerical answer of one of the following five quantities:

Class 1:	A	Area of surface required
Class 2:	H	Total heat transferred from one fluid to the other
Class 3:	t_2 or t_2'	Final temperature of either the warm or cool fluid
Class 4:	t_1 or t_1'	Initial temperature of either the warm or cool fluid
Class 5:	G or G'	Required weight of either the warm or cool fluid



A type of surface in which a refrigerant liquid is vaporized, cooling the air for a restaurant. The data given in these articles are applicable to the calculation of such coils when only sensible heat is removed from the air supply; both the final temperature and the quantity of heat can be computed

Referring to Col. 4, Table 1, for $M = 1.72$, find in Col. 2,

$$\frac{D_m}{D_L} = 0.478$$

In order to find D_L, the required large temperature difference, it is first necessary to find D_m.

$$H = G\,s\,(95 - 65)$$

$$= 5420 \times 30$$

$$= 162{,}600 \text{ Btu per hr}$$

$$H = A \times U \times D_m$$

$$162{,}600 = 9 \times 800 \times D_m$$

$$D_m = \frac{162{,}600}{9 \times 800} = 22.6 \text{ deg}$$

Substituting in the formula above,

$$\frac{22.6}{D_L} = 0.478$$

$$D_L = \frac{22.6}{0.478} = 47.2 \text{ deg}$$

Referring to Fig. 5, required initial temperature of water,

$$t_1' = t_1 - D_L = 95 - 47.2$$

$= 47.8$ deg required initial temperature of the water.

[*To be continued. Problems involving counter flow, the most confusing to solve, will be discussed.*—EDITOR.]

Silicosis—

[*Concluded from page* 88]

The following research projects are listed, therefore, for the consideration of the Foundation, whose headquarters are at Mellon Institute:

(A) Relationship between silicosis and tuberculosis. (B) The effect of other substances upon the action of silica in the body. It is claimed that some substances retard the action of silica on the lungs and that others seem to hasten the silica action. (C) Study of the mechanism by which silica exerts its injurious effects upon the body. Various explanations have been offered such as that the silica acts physically, or that the action is chemical or physio-chemical. (D) Research in the technic of roentgenography. Since it appears that to an ever increasing extent pre-employment medical examinations will include chest roentgenograms, a man may be hired or rejected on the basis of his x-ray film. Therefore, the very best technic that can be evolved is the least with which industry can be satisfied.

The report involved the weighing of findings gleaned in a number of industries, in hospitals and in research centers here and abroad. It concludes that on the basis of present knowledge, nine points are definitely known regarding silicosis. They are:

1. Silicosis results from the inhalation of dust containing free silica.
2. The time required for development of silicosis varies from a few years to 20 or more, depending on the concentration of silica particles in the air and the length of exposure.
3. Beginning silicosis is recognizable only by properly taken roentgen films (x-rays) of the chest.
4. Associated with silicosis is a marked predisposition to tuberculosis.
5. Silicosis can be prevented by protecting the industrial worker from inhaling silica dust. This may be accomplished by engineering measures.
6. Concentrations to which dust must be reduced in order to be safe have not been absolutely determined.
7. Industrial dusts, containing silica, are frequently not all silica, being mixed with other materials. Some of these substances may alter the silica action in the body.
8. Asbestos, a silicate, is the only dust other than free silica which has been shown to cause lung fibrosis and disability.
9. Simple—that is, uncomplicated—silicosis, as seen in industries in the United States, causes relatively little severe disability.

Importance of Design Control for Welded Piping Systems

By T. W. Greene*

THE utility of welding and the success obtained with it over a period of years has led to its general acceptance. Its general use for extremely high temperatures and pressures and combination of both is a testimony to its merits. In fact, welding has contributed to, if not been responsible for, the use of higher and higher pressures to effect a more efficient utilization of materials and economy in installation.

It is a desirable development to take advantage of the adaptability of welding to use thinner pipe, to increase the operating stresses, and to construct compact economical installations. With the use of the butt joint, ideal from a stress distribution standpoint, and with welds developing the full strength of pipe or base material, welding permits economies in the use of thinner material, and it is only a question of time until installations will generally be designed primarily on the basis of welded construction. To gain the full benefit of welding this development is inevitable, but it is important to recognize that sound engineering consideration must be given to various piping details, whether welded or fabricated by other means. In fact it is more important if operating stresses are to be justifiably increased for the danger necessarily increases. Moreover welding, because of its seal-tightness, even up to the breaking point or ultimate strength, often hides defects and inadequacies in design that might otherwise be manifested with a different type of construction.

"It is important to recognize that sound engineering consideration must be given to various piping details, whether welded or fabricated by other means. In fact, it is more important if operating stresses are to be justifiably increased."

Code for Pressure Piping

The *American Standards Association* published in 1935 a code for pressure piping which undoubtedly will stimulate the development and progress of welding in this field as much as the *A.S.M.E.* unfired pressure vessel code has influenced welding in its field. In this code, welding is not only recognized without limitations or restrictions, but assumes an important part throughout the code. The code acknowledges the advantages of welding in permitting thinner pipe to be used for welded construction than for threading. This varies for different services covered by the sections of the code, but as an example, the power piping section stipulates that for inspection purposes the minimum thickness of pipe wall shall be determined by the following formula:

$$t_m = \frac{PD}{2S} + C$$

where t_m = minimum pipe wall thickness, in.
P = maximum internal service pressure, lb per sq in.
D = actual outside diameter of pipe, in.
S = allowable stress in material, lb per sq in.
C = allowance for threading, mechanical strength, and/or corrosion, in.

The value of C used in the formula shall not be less than that given for the respective material in the following list:

Type of Pipe	Value of C in Inches
Threaded steel, wrought iron, or non-ferrous pipe	Depth of Thread
Plain end steel, wrought iron or non-ferrous pipe or tube for sizes above 1 in.	0.065

As the value of C to be used in the above formula for threaded pipe is 0.1 in. for pipe sizes 2½ in. and larger, the pipe thickness must be increased this amount over that required by the common pressure formula as against 0.065 in. for welding. Welding thus permits a saving of 17 to 11 per cent for standard pipe thicknesses 2½ in. to 10 in. respectively.

The value of design stress S in the above formula varies in different sections and services covered by the code, also for different materials. The stress values S in the power section for temperatures as high as 750 F are 9,000, 11,500 and 14,000 for seamless pipe grades A, B and C, respectively, lower values being stipulated for lap welded and other materials. Actually, however, the normal stresses are usually rather low because of the effect of the constant C, the necessity of allowing 12½ per cent manufacturer's tolerance for possible thinning, and the requirement of using the outside diameter of the pipe in the pressure formula, which errs on the side of safety.

The nominal stresses in pipe employed for the usual pressures encountered in every day practice are generally quite conservative. Table 1 shows these stresses for different pressures in a few typical pipe sizes. It is only where the diameter is large and the pressure high at the same time that really high stresses are developed. However, some industries, particularly the natural gas industry, of necessity use rather high stresses. The gas

*Process Development Dept., The Linde Air Products Co., New York, N. Y. Presented at the 1936 annual meeting of the *American Welding Society*, Cleveland, Ohio.

and air section of the code permits extremely high stresses for installations in compressor stations, cross-country transportation lines and systems outside of boundaries of cities and villages. The maximum allowable working pressure for such systems, according to the code, may be determined by the following formula:

$$P = \frac{2Yt}{FD}$$

where Y = yield point or yield strength for respective material and method of manufacture as determined by the code.
t = nominal or specified pipe wall thickness, in.
F = a factor not less than 1.4.
D = specified outside diameter of pipe, in.

This formula indicates that operating stresses may be as high as 71 per cent of the yield point. For materials having a yield point of 35,000 lb per sq in., the design operating stress may be as high as 25,000. Installations of extensive magnitude are actually in successful operation at stresses even higher.

Pressure Stresses Around Nozzles

Experience with overland lines and other installations has demonstrated that high pressure stresses, probably from 15,000 to 25,000 lb per sq in., are both safe and justified with welded construction for straight line joints with the understanding, of course, that the design has adequately provided for all external loadings and strains that may cause superimposition of stress. But every installation requires special fittings and fabricated specials. Moreover, in the fabrication of specials, the normal expected stresses may be increased many times due to the imposition of concentration of stresses or to bending, and this must be designed for if the construction is to be safe.

Practically all fabrication involves the welding of nozzles. It is important to examine the effect of removing a part of the pipe for a nozzle. The effect of an opening on the normal stress distribution can probably best be represented by a graphical illustration of stress lines as shown in Fig. 1. The plate is assumed under a uniform load P acting in one direction. The stresses set up by the force may be represented as flow lines as shown. These are uniformly distributed if the load is uniform and if there is no opening, and the concentration of the lines may be considered as an index of the stress intensity.

If a hole is cut in the plate, the flow or stress lines must transfer around the opening. Unfortunately, they will not distribute throughout the remaining metal but will take the shortest path, concentrating at the edge of the opening. It can be shown theoretically that for a plate stress in one dimension the stress intensity at the edge of the opening is three times that in the plate at a distance from the opening. Where the load stress is uniform in all directions, as in the head of a pressure vessel, the stress at the edge of the opening is theoretically twice the normal stress.

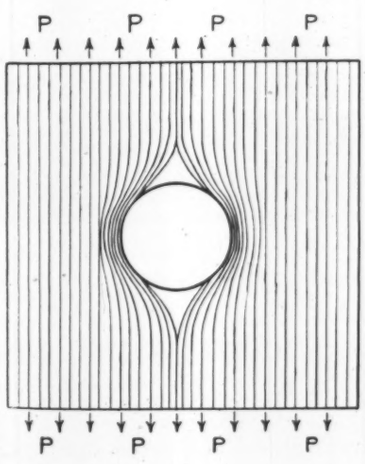


Fig. 1—Graphic illustration of stress concentration around openings

Table 1—Stress in Pipe for Different Pressures

Pipe Size, In.	Outside Diameter, In.	Wall Thickness, In.	Hoop Stresses (Lb per Sq In.) Under Pressures of			
			250 Lb	500 Lb	800 Lb	1800 Lb
6	6.625	0.280	2,800	5,600	9,000	20,000
10	10.75	0.307	4,400	8,800	14,000	31,500
20	20.00	0.3125	8,000	16,000	25,600	.....

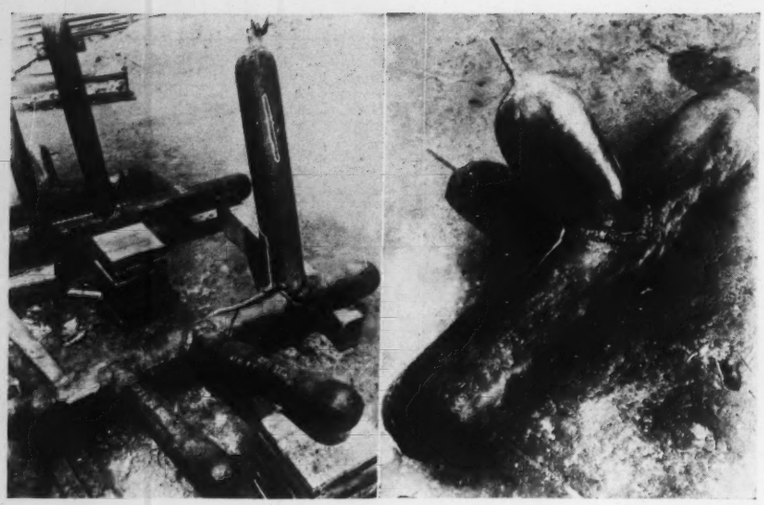
In pipe, which is subjected to a hoop stress and also to a longitudinal stress of half the value of the hoop stress, the theoretical concentration factor is somewhere between two and three. The attachment of the branch pipe or nozzle by welding of course reinforces the opening to some extent, but not enough to equal the pipe itself. Some tests have been made of nozzle connections both in pressure vessels and piping, and this subject is now under consideration by a special committee of the *American Standards Association,* which is planning to conduct extensive tests, looking toward setting up recommended practices to be incorporated in the code for pressure piping.

In studying this subject, it is of particular interest to review a few tests of headers made some time ago[1] on steel pipe with thicknesses required in power piping practices; the results are interesting and illuminating. Table 2 gives the different headers investigated. The headers were constructed with one to three nozzles welded into each header pipe. The wall thicknesses of the pipe were ⅜, ½ and ¾ in. in compliance with *Power Piping Society* specification for operating pressures of 250, 400 and 900 lb per sq in. The welding was done by competent oxy-acetylene operators with high strength welding rod and in every detail represented excellent construction.

The headers were tested hydrostatically to destruction, with elaborate strain gauge measurements being taken around the nozzles at known critical points as well as in the pipe away from nozzle connections, in order to determine the stress concentrations around the openings as compared with normal stresses in the pipe away from the openings. The results of these tests are shown in Tables 2 and 3.

It will be seen that these headers failed under hydrostatic pressures producing normal hoop stresses in the pipe of from 25,000 to 45,000 lb per sq in. or, on an average, less than 75 per cent of the expected strength of the pipe based on a minimum strength of 45,000 to 55,000 lb per sq in. specified for the low carbon pipe material. Of particular interest is the method of failure. Failure in every case occurred by the longitudinal splitting of the pipe at the top of the header where the nozzle connection makes a right angle intersection with the header pipe. Figs. 2 and 3 show the failure of these headers. This is the critical point in nozzle or branch attachments as high concentrated stress occurs at this

[1]By the *Power Piping Society* and The Linde Air Products Co.



❖

Fig. 2 (left)—Failure of Header *B*

Header size 10 in. x 0.75 in. wall, seamless
Nozzle size 10 in. x 0.75 in. wall, seamless
8 in. x 0.625 in. wall, lap welded
6 in. x 0.50 in. wall, lap welded
Failure occurred at 6,500 lb per sq in. pressure, with the fiber stress in the header 46,500 lb per sq in.

Fig. 3 (right)—Failure in Header *E*

Header size 12 in. x 0.5 in. wall, lap welded
Nozzle size 12 in. x 0.5 in. wall, lap welded
Header failed at 2,755 lb per sq in.; stress 35,100 lb per sq in.

❖

point. The reason for this is evident from the explanation previously given of the stress transfer around an opening. The hoop stresses set up in the header pipe resisting the internal pressure must transfer around the nozzle opening. They do not transfer evenly either in the header or branch pipe but concentrate at the critical point where the branch makes a right angle intersection with the header pipe.

In Table 3 is presented the stress-raising factor determined for the various size nozzles in these header tests. These were obtained by strain gauge measurements at which the yield point of the material was exceeded at the critical point around the nozzle as compared to the yielding of the header pipe at a distance from any opening. It will be seen that the stresses at the nozzles were from 1.2 to more than two times the normal hoop tension of the pipe.

It should be emphasized that in spite of the fact that high stresses are concentrated around the branch openings and that the headers failed at approximately 75 per cent of the strength that would be developed with the pipe without openings, the headers are amply safe for the design working pressure. An average factor of safety of seven was developed as shown in Table 3; this is due to the conservative design required in power piping practice. The normal stress in piping for usual pressures rarely exceeds 3,000 to 6,000 lb per sq in. Thus, if a stress concentration of twice this amount occurs as shown in these tests, the maximum stress is still relatively low, and the factor of safety is ample.

It is of interest to examine the effect of such stress concentration with the high pressure stresses given in Table 1. If high stress of 15,000 to 25,000 lb per sq in., which is safe for a straight run of pipe, is used in the design of headers, branch connections, drips and other fabrication details, it may be possible to have stresses as high as 30,000 to 50,000 lb per sq in. at critical points in the header. It can readily be seen that such practice is not safe. In fact, instances are known where headers designed on such high stresses have failed through the critical points under tests of only 1½ times the expected working pressure.

Superimposition of Bending Stresses

In all piping systems expansion and contraction are factors of more or less importance, depending upon the temperature change. Means must be provided for movement either by expansion joints, bends or in the flexibility of the system itself.

Header *A* of the previously mentioned tests was sub-

Table 2—Test of Power Piping Headers

Header Test No.	Header Pipe Size, In.	Header Wall Thickness, In.	Nozzle Pipe Size, In.	Nozzle Wall Thickness, In.	Allowable Working Pressure in Header Pipe, Lb per Sq In.[a]	Hydrostatic Test Results: Bursting Pressure, Lb per Sq In.	Hydrostatic Test Results: Stress in Header at Failure, Lb per Sq In.[b]	Failure
A	10	0.365	10 8 6	0.365 0.322 0.280	250	1,705	25,100	8 in. nozzle weld cracked at 90 deg intersection
B	10	0.750	10 8 6	0.750 0.625 0.50	900	6,500	46,500	Header rupture through 90 deg intersection with 10 in. nozzle
E	12	0.500	12	0.5	400	2,755	35,100	Header rupture through 90 deg intersection with 12 in. branch

[a] *Power Piping Society* specification.
[b] Stress=$PD/2t$, Barlow's formula (D=O.D.).

Table 3—Comparison of Relative Stresses

(Stresses around branch connection at 90 deg intersection point to normal stresses in header removed from opening.)

Header No.	Header Pipe Size, In.	Header Wall Thickness, In.	Allowable[a] Working Pressure, Lb per Sq In.	Allowable[a] Working Stress, Lb per Sq In.	Allowable[a] Factor of Safety Bursting Strength	Ratio = Stress Around Nozzle Opening[b] / Normal Stress in Header Pipe: For 12 In. Branch	For 10 In. Branch	For 8 In. Branch	For 6 In. Branch
A	10	0.365	250	3,700	6.8	.....	2.28	2.00	2.00
B	10	0.750	900	6,400	7.2	.....	1.42	1.41	1.19
E	12	0.500	400	5,100	6.9	1.67	.....	.....	.....

[a] *Power Piping Society* specification.
[b] Stress determined from strain gauge reading to determine pressure that caused yielding of the material.

jected to a special test in which the 6 in. and 8 in. branches were deflected by means of a turnbuckle, Fig. 4. In this test, the 6 in. branch was deflected ½ in. at a point 54 in. from the header, and the 8 in. pipe, about half this amount. Purpose of this test was to simulate the force that might be thrown on a nozzle connection through expansion and contraction in the branch piping. The test was somewhat severe and represented a condition rather unusual for actual installations, where two branches would rarely be deflected toward each other when placed so close together. Header *A* was tested to destruction under the imposition of the turnbuckle force.

Fig. 4—Header *A*, showing location of the groups of gauge lines for header tests. The boxlike group is for two transverse and two longitudinal gauge lines for measuring the deformation of the header pipe removed from any opening influence. Turnbuckle for imposing bending force on branch connections is illustrated

Although this deflection test in header *A* was somewhat impractical, it is interesting to determine the nature of the stresses set up and the action of the header under such external force. To deflect the 6 in. pipe ½ in. means that a bending stress (based upon the common formulas of a cantilever beam, rigidly held) of 51,000 lb per sq in., would be set up, providing the elastic limit was not passed. In other words, it would be expected that the branches would be permanently bent. As a matter of fact, the deflection of ½ in. did not permanently distort the header nor were stresses anywhere near this magnitude imposed, the reason being that in header construction the branches are not rigid cantilever beams, for the header pipe bends and deforms as the branches are deflected. The metal between the two branches was thrown into compression as shown by the strain gauge measurements and had readings been taken on the opposite side, they would have shown, no doubt, tension.

Table 4 gives stress distribution around the 6 and 8 in. branches and in the header pipe at the points measured. It also indicates the increase of stress at 1,000 lb per sq in. internal pressure imposed by the deflection of the two branches. It will be seen that stresses imposed by deflection were superimposed on those measured under pressure alone.

Stress Relieving of Piping

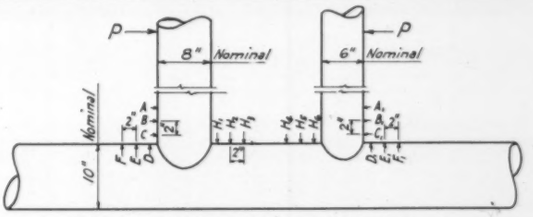
Stress relieving of welded piping has always been a moot question. In spite of the study and experimentation devoted to the subject of residual stress, little definite knowledge yet exists, and one must necessarily rely upon practical application for guidance. One fact should be borne in mind—that residual stresses are not necessarily superimposed on those caused by pressure or bending which is unlike the condition of stress superimposition under different external forces. Where the individual fibers of the metal are subjected to stress approaching the elastic limit of the material, there occurs unavoidably a readjustment and ironing out of stresses. In considering this problem, one must face the fact that millions of welded pipe joints and thousands of pressure vessels "un-stress relieved" have given satisfactory service.

Fortunately, piping offers one of the most favorable shapes from the standpoint of residual stresses. The *A.S.A.* piping code requires stress relieving only when the pipe wall thickness is ¾ in. or greater. This division is of course somewhat arbitrary but it is based upon consideration of two factors: (1) rigidity, which naturally becomes important when the thickness reaches a dimension as great as ¾ in., and (2) the appreciation of the pressure hazard, as such thick walls are generally used with high pressures. The division also follows somewhat that set up and successfully applied in the pressure vessel field. Experience and practice have proved that the provisions of the piping code are safe, and it is believed that they can be employed as a practical guide.

Weld Quality

No mention has been made of weld quality, which is of course, most essential. Data have been presented

Table 4



Measured Superimposed Bending Stress from Deflection of 6 and 8 inch Branches Header "A".

Position	A	B	C	D	E	F
			Stress in Girth Direction			
Pressure 0*	800	2000	11,400	7,000	7,100	6,400
Pressure 1,000*	6,600	-1,000	Y.P.	18,400	5,600	1,800
			Stress in Longitudinal Direction			
Pressure 0	9,500	10,000	13,000	11,000	8,700	6,400
Pressure 1,000	2,500	4,100	14,500	3,400	1,700	2,000

Position	A_1	B_1	C_1	D_1	E_1	F_1
			Stress in Girth Direction			
Pressure 0	-4,000	500	27,800	22,000	7000	11,900
Pressure 1,000	-2,000	-2000	Y.P.	Y.P.	10,000*	8,600
			Stress in Longitudinal Direction			
Pressure 0	16,800	19,700	29,400	17,100	10,200	9,600
Pressure 1,000	10,200	8,100	15,400	18,200	5,100	2,500

Position	H_1	H_2	H_3	H_4	H_5	H_6
			Stress in Girth Direction			
Pressure 0	-16,600	-7,600	-6,700	-8,400	-8,800	-19,800
Pressure 1,000	-7,200	-8,600	-7,900	-7,800	-9,500	-17,200
			Stress in Longitudinal Direction			
Pressure 0	-19,300	-14,200	-12,200	-13,000	-14,300	-18,000
Pressure 1,000	-14,200	-13,100	-9,300	-12,800	-14,500	-15,600

* Header "A" was previously tested to 1,000 lb/sq in. pressure to investigate yielding around nozzle. Pressure was then released and nozzles deflected. The stresses reported at 0 pressure are those resulting from deflection of nozzles. Stresses reported at 1000 lb pressure are additional stresses as compared to stresses previously measured under 1000 lb pressure without deflection of nozzles.

before the *American Welding Society* on tension tests of full pipe joints which showed that weld quality is more important than stress relieving of pipe welds.[2] Of particular harm is the lack of penetration or fusion at the bottom of the butt joint, for the effect is that of a notch. In this case the concentration of stress is serious because it superimposes and accentuates the normal stress on the joint.

In appreciation of this factor, liners have been advocated at times to back up the weld and have been applied to some extent for electric welded joints. However, they resist the flow in the line and by exercising a little care in spacing and welding the first bead, a satisfactory butt welded joint can be obtained. For gas welding, liners are not advocated since by proper control of the flame and welding rod, full penetration can be assured to the bottom of the vee.

With improvement and advancement in welding, welds of consistently high quality are assured, but such assurance, as pointed out in this paper, has not eliminated the necessity of applying sound engineering consideration to important details of welded piping.

[2] "Weld Ductility Requirements for Welded Pressure Piping," by T. W. Greene. *Journal* of the *American Welding Society*, April, 1932.

Air Conditioning for Hospitals and in Normal Life

PAPERS on hospital air conditioning and the application of air conditioning in normal life were read before the Harvard University Tercentenary Symposium on "The Environment and Its Effects upon Man" at Boston last August and have recently been made generally available in the December issue of the *Journal of Industrial Hygiene and Toxicology*. C. P. Yaglou, Department of Industrial Hygiene, Harvard School of Public Health, is the author of the former, and Philip Drinker, Department of Industrial Hygiene, Harvard School of Public Health, prepared the latter.

In his paper, Professor Yaglou said that the application of air conditioning to hospitals is now mainly confined to four or five wards in which partial or complete air conditioning has proved of sufficient value to justify its use, these wards being nurseries for premature infants, anesthesia and operating rooms, oxygen therapy chambers, heat therapy rooms or cabinets, and allergic wards. Application to delivery and maternity rooms is believed to be a secondary consideration, at least in the North, he said. The most popular application is in operating rooms and nurseries.

He then discussed the objectives of air conditioning as applied to these five wards, and the special problems that arise in each case.

In summarizing the conclusions of studies reported on the first-mentioned application (premature nurseries) he stated the best chances for life in premature infants are created by maintaining a relative humidity of 65 per cent or more in the nursery and by providing a uniform external temperature just sufficiently high to keep the body temperature within normal limits. A humidity of 65 per cent cannot be obtained without resorting to mechanical equipment.

Air conditioning of operating rooms is, he said, mainly concerned with the welfare of the patient, comfort and efficiency of the surgeon and his personnel, and with the safety of the whole procedure. He pointed out that to prevent accumulation of static charges within apparatus or on persons coming near to it, the measures proposed by the committee on anesthesia accidents of the *American Medical Association* are humidification of air to between 55 and 60 per cent relative humidity, as well as grounding the apparatus and operating tables and using conducting floors and shoes. The significant factor is the absolute humidity, rather than the relative humidity, because upon it depends the electrical conductivity of the air. The ill effects of high operating room temperatures were then described, and in conclusion it was stated that with a relative humidity of 55 to 60 per cent, a temperature of 80 F in warm weather and between 72 and 75 F in cold weather will probably prove satisfactory.

Air conditioning in oxygen therapy and fever therapy was then considered in some detail, as was the application of air conditioning in the production of systemic fever. Following this, air conditioning in the control of allergic conditions was reviewed.

In conclusion, Professor Yaglou said that for general hospital wards the problem is one of ventilation rather than conditioning. Insulation against heat and sound is important, more so than is humidification in winter. The preferred method of heating is forced circulation hot water, he stated. The preferred exhaust ventilation system uses one or more fans situated in the attic or in a penthouse with two or more vertical air ducts run up from the ground floor ceiling to the exhaust fan chambers, connecting, on the way up, with horizontal branches at the ceiling of each corridor.

In his discussion of the application of air conditioning in normal life, Professor Drinker said that air conditioning more than justifies itself in making the atmosphere more comfortable than it otherwise would be. Better work is done in moderate, pleasant atmospheres than in extremes of any sort. The success of many industrial processes depends upon environmental control. In his opinion, such reasons are enough, and the engineer need not ask of hygienists or physicians for data which, he said, cannot now be supplied.

The objectives of air conditioning were reviewed and the comfort chart and its basis were described by the author. Such factors as acclimatization, the effect of which he considers one of the most interesting in air conditioning, clothing, radiant vs. convected heat, etc., were treated in some detail.

It seems likely that the application of ultra-violet radiations to the killing of bacteria in recirculated air may earn a place in air conditioning, he said. It may be that in the future germ free air will become as necessary as germ free water or milk and will be gauged by tests somewhat analogous to those now used for water or milk.

Odors, ionization and the effect of proper air conditions on furnishings were also considered.

Some of the individual branch ducts for the 63 air conditioned spaces, each with its heating coil and cooling coil

Unique Air Conditioning System Serves New Industrial Building

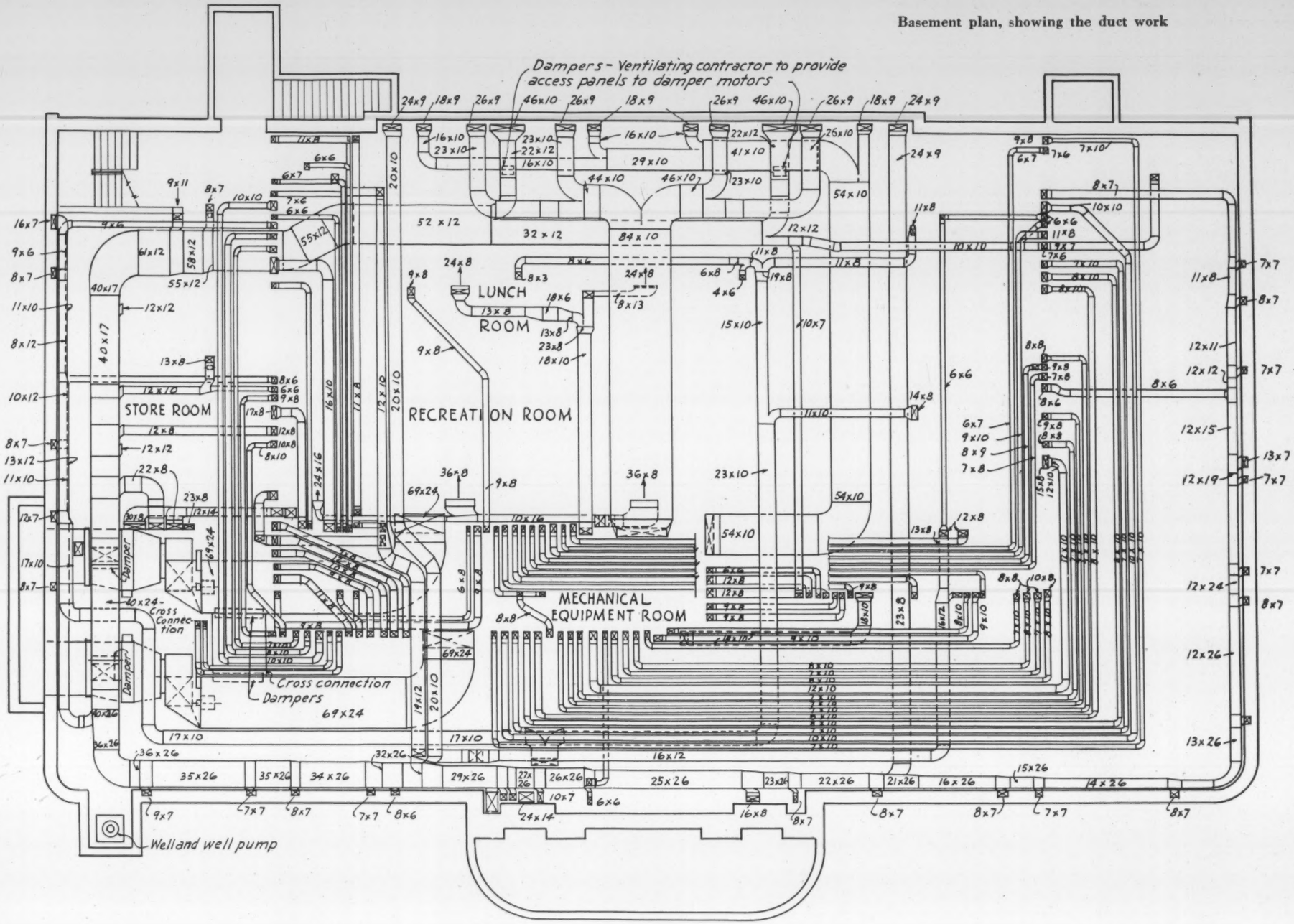
By Robert E. Hattis*

National Aluminate Corp's. new windowless building, now under construction to house its offices and industrial research laboratories, is air conditioned by a system that incorporates unique features. Because of the building construction and insulation, with high heat gains from lighting and other internal heat sources, some rooms may require cooling while others will require heating. Individual branch ducts therefore supply the 63 air conditioned spaces, and each duct has a cooling coil and a heating coil, the first supplied with cold well water and the second with hot water from a heat exchanger; water flow to the coils is under thermostatic control. . . . The description of the heating and air conditioning of this building is an example of the importance of engineering in air conditioning design, and of how a natural resource—in this case, 53 F well water—may be used to reduce the cost of air conditioning

A WINDOWLESS, completely air conditioned building to house the research laboratories and offices of the National Aluminate Corp. in the Clearing industrial district near Chicago is under construction and is scheduled for occupancy next month. The air conditioning system is of novel design, incorporating provisions for heating and cooling the various offices and laboratories independently of each other; because of the windowless construction and the resulting high heat loads due to the lighting, and also because the absence of windows and the insulation of the building reduces heat losses in winter, it will be necessary to cool some of the interior rooms when others will require heating. Therefore, each conditioned space is supplied by an individual branch duct, and each duct has its own heating coils and cooling coils, supplied with hot and cold well water respectively. There is probably more sheet metal duct work per cubic foot of building volume in this building than in any other conditioned structure serving a comparable purpose.

*Consulting Engineer, Chicago, Ill.

Basement plan, showing the duct work



Why Windowless Construction Was Adopted

The building is two stories in height, 135 ft by 100 ft, and is constructed of white terra cotta walls with decorative bands and entrance. It consists of general and private offices, general and special laboratories for research in the chemical treatment of water for boiler feed and other industrial purposes, a cafeteria, recreation room, etc. The officials of the National Aluminate Corp. and the architects, Ambrose C. Cramer, Inc., decided upon the windowless type of construction for the following reasons:

1. In an industrial district the outdoor air carries noise, dust and odors from the busy plants and railroad locomotives. Generally, the view from windows is not attractive. There is nothing to be gained from windows which must be kept closed to keep out noise, dust and odors and through which the view is not inspiring.

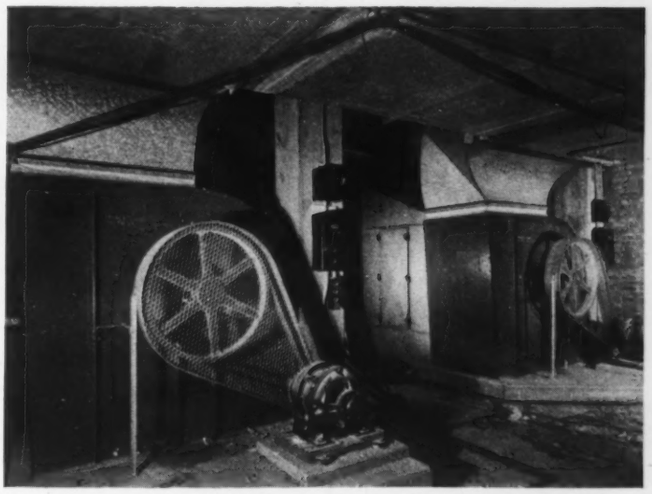
2. Experience in their present offices indicated great discomfort from heat in summer, and cold drafts in winter. Air conditioning to produce comfortable conditions in summer and proper temperature and humidity in winter was decided upon, to facilitate healthier and more efficient working conditions. The cooling load in summer is increased greatly by windows. Proper humidification in winter is difficult with windows in cold weather because of condensation. Windows thus would be a handicap to air conditioning.

3. Light from windows, as well as ventilation, is a reason for their place in buildings. Even with good light outside, there is no uniformity of lighting inside. When the sun shines through, the glare is objectionable, and frequently, the outdoor light is not adequate or is entirely absent.

4. To benefit from natural light from windows, buildings are designed shallow in depth and often require courts or other shapes (L, T, H, etc.) to expose as much wall surface to the outdoors as possible. This involves more of the costly exterior wall surface per sq ft of usable floor space, and the portions of the property not covered by building are not fully used. Also, the heating and cooling loads are increased. Long corridors connecting the wings are required. A windowless building can be made a solid square or rectangle with minimum exterior wall and the greatest compactness of inside spaces.

5. The windowless construction could be expected to result in a saving of approximately 20 per cent in building cost as compared with a more conventional type of building with windows. With complete insulation and no losses or gains of heat through glass areas, substantial economies in heating and air conditioning operating costs would be made. (Were it not for the necessity of admitting outside air for ventilation, the building could be heated in —10 F weather by the heat from the lighting alone.)

Having decided on a windowless building, the problems of lighting and air conditioning had to be solved. It was decided to provide daylight with indirect lighting fixtures having a mixture of incandescent yellowish light and mercury vapor bluish light, producing day light by adding the two colors of the light sources in the proper proportions, instead of subtracting some yellow light through a blue glass and losing about ⅓ of the available light. As brightly lighted rooms are more cheerful and facilitate speedier work with equal accuracy, high lighting intensities (20 foot-candles or more) were decided upon. Utility outlets were provided essentially for electrically operated office accessories, as desks and other types of local lighting will not be needed. A certain amount of ultra-violet light from the mercury vapor lamps produces health giving qualities not usually available from incandescent lamps alone.

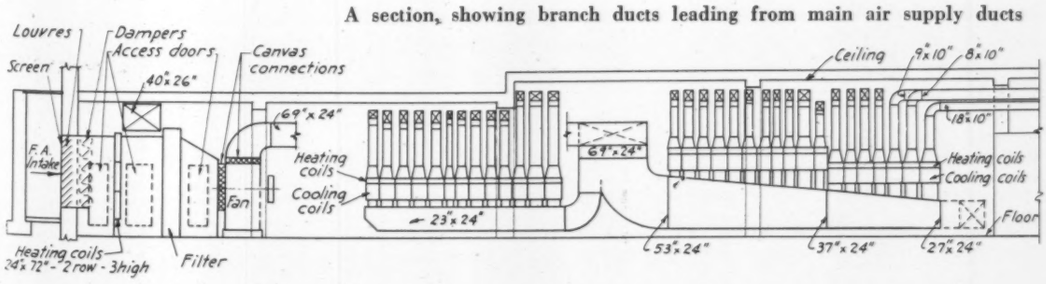


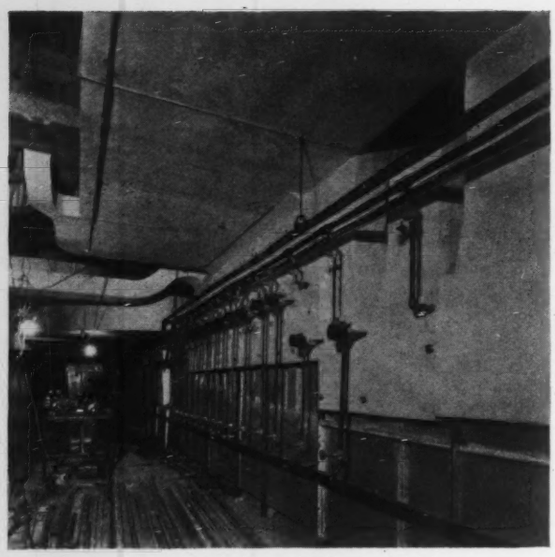
Main supply fans

Air Conditioning Essential

Of course, with a windowless building, proper air conditioning is essential. A number of variables had to be contended with. This particular building contains the research laboratories and the offices, the laboratory portion comprising a large general laboratory and several smaller laboratories. The office portion of the building contains a large general office and many smaller offices. The individual occupants of the smaller spaces do not all want the same temperature conditions maintained, and they may vary their requirements from time to time. Because of the great amount of light provided, the heat from the electric lights in most spaces is more than enough to take care of the much reduced heat losses through well insulated walls and roofs, even in extreme cold weather—involving cooling in winter with the lights on and heating with the lights off. The smaller offices are not always occupied, and alternate heating and cooling is required. The laboratory spaces have large heat producing devices which, with the heat from lights and the occupants, require cooling even in winter. Interior spaces with no heat losses always require cooling. So a scheme of air

A section, showing branch ducts leading from main air supply ducts





Another view of the branch ducts after the insulation had been applied

conditioning had to be designed which would do two things:

1. Maintain the variable temperature conditions required by the feelings and habits of the occupants.
2. Provide heating or cooling alternately due to variable conditions in the use of the spaces, as well as the outdoor weather. This meant that some rooms would have to be heated while others required cooling, etc.

Of course, ventilation had to be provided at all times during occupancy. And humidification had to be provided in winter. Some laboratory spaces with escaping fumes from certain experiments or accidental spilling of volatile chemicals had to be equipped for emergency exhaust and isolation of the fumes.

Two practically identical air conditioning systems were provided, each serving about one-half of the building. These two systems are cross connected so that in an emergency due to trouble in one system, the entire building could be handled in a measure by the other system. Each system is equipped to take in part or all or no outside air, which air is tempered with heating coils. Some or all of the room air is recirculated, the mixture of fresh and recirculated air being filtered through automatic oil filters, humidified in winter and then pulled through a fan and blown from a main duct to a branch duct for every conditioned space.

In this branch duct is a cooling coil and also a heating coil. The duct then goes to the conditioned space, diffusing the air at or near the ceiling. Recirculated air is returned from grilles at the floor, and is conveyed to basement trunk ducts through chases, which are insulated with ½ in. corkboard, in the outside walls, and through sheet metal ducts in interior partitions. As the various conditioned spaces are separated by tight partitions with tight doors for privacy and localization of noises, the excess of air supplied over that which is returned is vented to furred corridor ceiling spaces and pulled out of those spaces by roof fan ventilators. Rooms with fume odors have the vents connected solidly by ducts to their roof fan ventilation.

Humidification in winter is controlled centrally, as very little moisture is added internally by the process work or occupants. Every space in the building is heated by ducts, no direct radiators being used. Each air conditioned space has a thermostat which sends cold well water through its cooling coil or circulates hot water through its heating coil as required by the conditions in the space. Cooling water and heating water are always on tap, ready for instantaneous use through the proper coils. All of these heating and cooling coils are situated in a basement machine room for ease of servicing.

In addition to the air conditioning system, a fume exhaust system exhausts acid and noxious fumes, and a toilet exhaust system keeps the toilet rooms fresh.

Details of the Installation

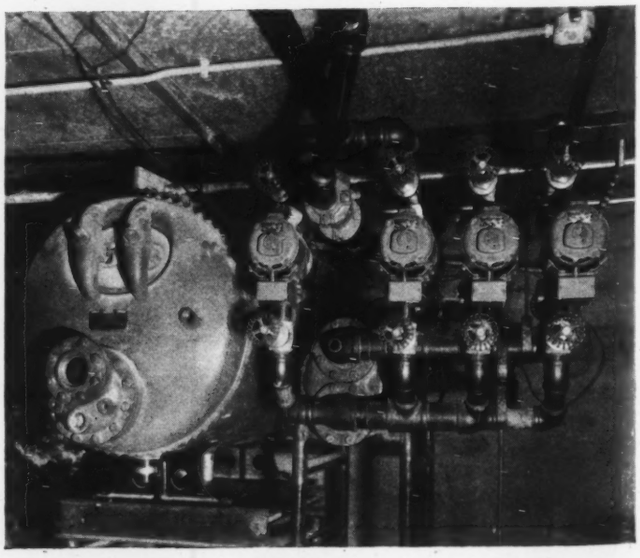
Equipment for Pumping Cool Water to Coils

Two wells about 300 ft deep deliver water by means of turbine pumps electrically driven. The water from the pumps flows through the cooling coils as admitted by throttling valves controlled by a thermostat in the space supplied with this air. After flowing through the coil the water is discharged to the city sewer.

A pneumatic pressure tank with pressure switches, properly set to start first one well pump and then the second well pump permits the use of only the amount of water required for cooling. The water flows through the coils counterflow, entering the coils at 53 F and, under maximum cooling conditions, a 20 deg rise in the cooling water is obtained.

Pumping and Supplying Hot Water to Coils

Hot water for circulation through the heating coils is obtained by means of a heat exchanger with steam in the



The heat exchanger for supplying hot water to the branch duct heating coils

shell and water in copper coils within the shell. Steam is admitted as required to maintain a water temperature of 200 F by means of an aquastat in the water controlling a throttling valve in the steam supply line.

Provision is made for expansion of the water and make-up by means of a cushion tank and a suitable hot water heating system type of governor. The hot water is circulated through the coils by a quiet type circulating pump and admitted to each coil by means of a throttling valve controlled by a thermostat in the room supplied.

Controlling Flow of Water to Coils

There are 63 individual conditioned spaces in the building, each of which has an air supply duct with a cooling coil and a heating coil. The flow of well water through the cooling coil or hot water through the heating coil is controlled by a thermostatic valve in the water supply to each coil, both of these thermostatic valves being controlled by a thermostat in the conditioned space. When the room is colder than the temperature setting of the thermostat, heat is called for and the heating valve opens. When the room is brought up to the temperature the heating valve stays in a throttled position depending upon the amount of heat required. If, due to internal or external conditions, the room temperature rises above the thermostat setting, the heating valve closes. If the room temperature still is above the setting the cooling valve opens gradually to keep the room temperature from rising, and *vice versa.*

Heat Losses and Heat from Lights Compared

It is interesting to compare the quantity of heat given off by the modern high intensity light sources and the heat transmission losses from the well insulated windowless rooms in —10 F weather:

Room	Heat loss, Btu per hr	Heat from lights Btu per hr
Gen. lab., 1st fl	18,705	67,300
Gen. office, top fl	32,210	45,600
Lower floor office	2,910	4,600
Top floor office	3,900	4,600

Corner rooms on the top floor require more heat than the lights furnish. Of course, since the spaces are ventilated with outside air, in cold weather the cooling required in the spaces is accomplished by keeping the air supplied to the rooms below room temperature. When, in the heating season, the outside air will not cool the recirculated air sufficiently to cool the rooms, then cooling by well water is required in winter. Of course, internal sources of heat increase the requirement for cooling in winter. With a windowless building, there are many interior spaces with no outside exposure that require cooling at all times.

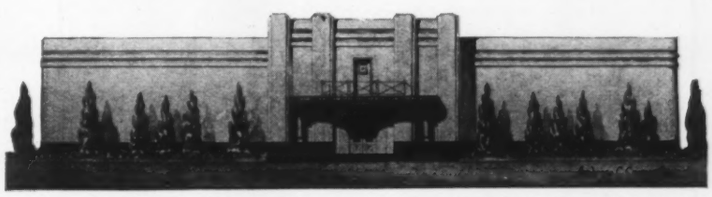
The walls of this building consist of 15 in. of masonry with 2 in. furring strips and metal lath and plaster. The roof consists of concrete joist construction with 2½ in. concrete between the joists, 2 in. corkboard, and tar and gravel roofing.

Seventeen Hp Produce 90 Tons

For economy in air conditioning, each installation must be regarded as an individual engineering problem and the requirements and peculiarities of the specific job must be allowed for in the engineering design of the system. Not only must the air conditioning engineer be concerned with the actual mechanical equipment for air conditioning, but he must also decide such questions as to the extent insulation should be applied, increasing first costs, of course, but resulting in lower over-all owning and operating costs.

Frequently it is possible to take advantage of natural conditions, such as the availability of the 53 F well water in the case under consideration. Because of the availability of this water, it was possible to handle this cooling load, which totals 90 tons, with two 10 hp well pumps, loaded about 85 per cent. Thus, 17 hp produce 90 tons of cooling, without the use of condensing water, or about 0.19 hp per ton. At 2c per kwhr this means (figuring 1 kw input for 1 hp output) that this 90 ton job at maximum load condition will cost 34c per hr for cooling effect.

The author was responsible for the design of the air conditioning and heating of this building. The contractors installing the system are the Narowetz Heating and Ventilating Co. for the ventilating work and the Northern Plumbing and Heating Co. for the steamfitting work.



Significance of the Reynolds Number

WITH a view to making the significance of the Reynolds number clear to a wide audience, Prof. Boris A. Bakhmeteff of Columbia University was asked by the applied mechanics division and the metropolitan section of the *American Society of Mechanical Engineers* to deliver a lecture on the subject at a meeting held in New York City last year. Professor Bakhmeteff later prepared a summary of his lecture for publication.[1]

The following paragraphs are a brief excerpt from the published summary, with the *A. S. M. E.'s* permission. It is felt that this excerpt indicates with exceptional clarity the significance of the Reynolds number in the flow of fluids in pipes.

The existence of two different types of motion has been mentioned. The classical example, however, is the well-known distinction between "laminar" and "turbulent" flow in pipes, first established by Osborne Reynolds[2] and elucidated in Fig. 1. The broken line indicates the change of the law of resistance. The latter is at first proportional to the first power of velocity, this being in the zone of laminar flow where the filaments actually constitute congruent streamlines conserving their identity. Then in the zone of turbulent flow, reached at higher velocities, the resistance varies almost as the square of the velocity, and the highly increased losses are principally caused by a process of turbulent mixing, a conventional term used to describe the altogether irregular transversal and eddy movements of the individual particles.

Between lies a transition zone with a demarcating "critical" velocity. The Reynolds number is a criterion demarcating the two states of flow. $R_{cr} \cong 2000$, indicated in the drawing, is the customary value of a delimitating "lower critical" velocity below which the flow pattern is always laminar, so that even an initially turbulent movement settles down into a stabilized streamline motion.

Fluid motion in the laminar state, with a permanent streamline pattern, was qualified by Reynolds as "stable," this "stability" feature being lost in transition to the turbulent state, which is essentially "unstable."

To invoke a comparison, imagine a procession of people or the marching of a military detachment; when the pace is slow and the "depth" of the columns is not excessive, order and alignment are easily preserved. Increase the speed or the depth of the ranks and stability of form becomes imperiled. A step further and utter confusion may be on hand. The stampede of a panicky crowd or a herd of frightened animals may serve as an example. The heavier the individual units (cavalry vs. infantry; elephants, etc.) the greater the danger. Obviously the size of the group, its speed, and its ponderosity are factors promoting instability. On the contrary, if by some internal tie the relative internal mobility between the units were to be reduced, stability would be enhanced. By analogy, in pipe flow the diameter, the velocity, and the density will be unstabilizing agencies, while viscosity, which reduces internal mobility, will work for stability. The ratio of these factors $DU\rho/\mu$ finds symbolical expression in the Reynolds number, the numerical value of which thus becomes a relative index of instability.

In a pipe the critical value of the Reynolds number directly differentiates the two possible types of motion, which in their initial stages are illustrated by Fig. 2.

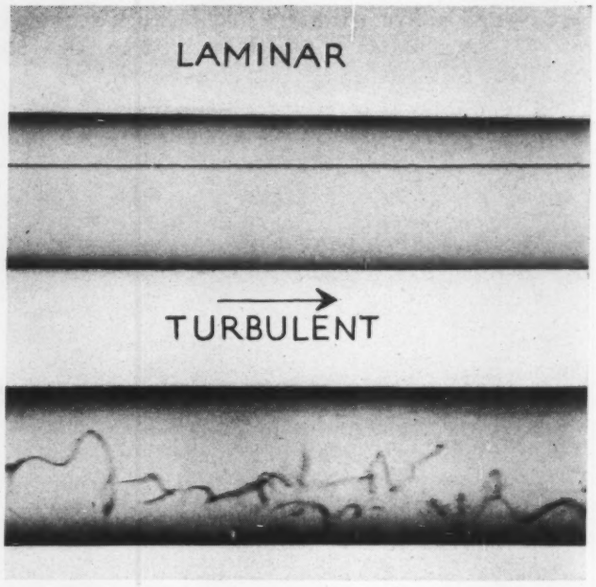


Fig. 2—Turbulence originating in a Reynolds apparatus. The dark line represents a colored filament

[1] "The Reynolds Number—A Simplified Explanation of This Important Quantity and Examples of Its Use in Aerodynamics and Hydraulics," by Boris A. Bakhmeteff. *Mechanical Engineering*, October, 1936, pp. 625-630.

[2] "An Experimental Investigation of the Circumstances which Determine whether the Motion of Water shall be Direct or Sinuous, and of the Law of Resistance in Parallel Channels," by Osborne Reynolds, *Philosophical Transactions* of the *Royal Society of London*, Series A, Vol. 174, Part 3, 1883, pp. 935-982.

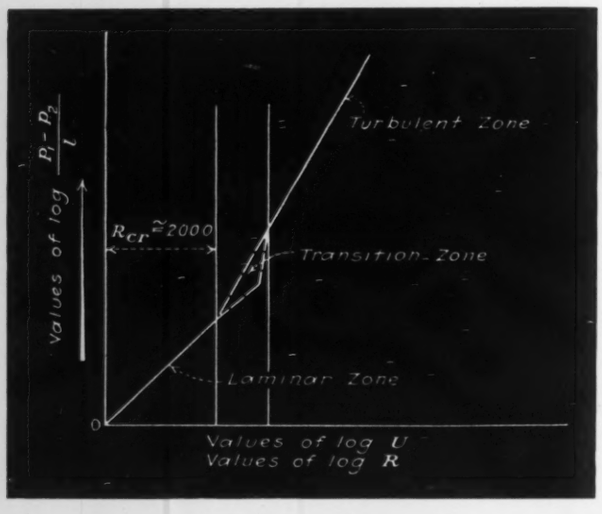


Fig. 1—The Reynolds diagram illustrating laminar and turbulent motion in a pipe

R = Reynolds number
U = velocity of flow
$\frac{p_1 - p_2}{l}$ = pressure loss gradient

Flow Meter Installation

Location of Orifice, Use of Straightening Vanes, and the Problem of Pulsating Flow

THE following information on the proper location of flow meter orifices, the use of straightening vanes in piping to eliminate disturbances in flow, and the measurement of pulsating flow, has been taken, with the permission of the authors, Louis Gess[1] and J. O. Feldmark,[1] from their "Flow Meter Engineering Handbook."[2]

Selection of Orifice Location

After a flow meter orifice plate has been correctly designed, the next step consists in the proper choice of the orifice location with regard to bends and fittings. Such a selection plays an important part in the correct transmission of the differential pressure created by the orifice plate. Numerous cases are known where, regardless of accurate orifice design, the meter results were entirely unsatisfactory on account of faulty orifice locations. It is therefore of the utmost importance to place the orifice at such a point in the pipe line where all effects of flow disturbances created by bends and fittings are eliminated.

As a rule, the best choice of an orifice location is a pair of flanges preceded by a long straight run of pipe, and followed by at least five diameters of straight length on the downstream side. However, in practice such installations are not always available, and it therefore becomes necessary to determine the minimum length of straight pipe required in order to get satisfactory metering results.

These pipe lengths usually vary with the orifice ratio and the type of fittings preceding the orifice plate and are arrived at in the manner indicated by the tables in the next column.

Straightening Vanes

One of the difficult problems in flow measurement is a swirling flow of the fluid, where the lines of the flow are not parallel with the axis of the pipe but have a swirling or helical motion. Such conditions are usually caused by various fittings on the inlet side of the orifice plate, when installed at a point where the required length of straight pipe on the upstream side is less than the amount specified above.

To make such installations suitable for flow measurement, straightening vanes must be inserted in the pipe to break up the disturbances in the flow and to eliminate the swirls, cross-currents and eddies created by the fittings preceding the orifice plate. Straightening vanes also make it possible to shorten the required length of straight pipe ahead of the orifice plate. The only requirement for such installations is a minimum distance of at least five to six diameters of straight pipe between the vanes and the orifice plate, regardless of the type of fitting that creates the flow irregularity.

Straightening vanes can be made of sheet metal shaped to make the flow parallel to the axis of the pipe by dividing it into several small streams, as shown in Fig. 1. They can also be of the tubular type, as shown in Fig. 2.

The construction of the vanes must be such that the largest cross-sectional dimension *a*, *b*, or *c* of any vane

[1]Flow Meter Engineering Dept., Brown Instrument Co., Philadelphia, Pa.
[2]Published by Brown Instrument Co.

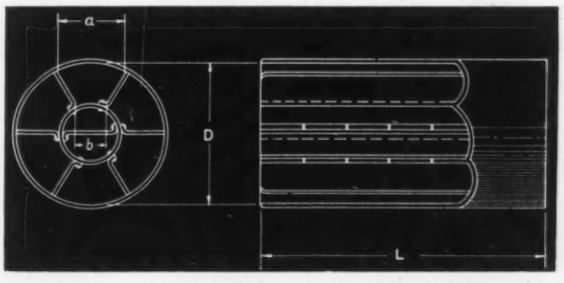
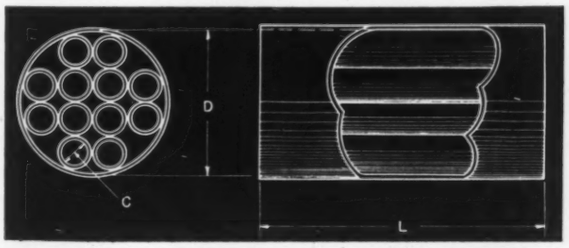


Fig. 1—Straightening vanes—sheet metal type

Fig. 2—Straightening vanes—tubular type



Minimum Number of Straight Pipe Diameters Between Orifice Plate and Upstream Fittings

Type of Fittings Preceding Orifice Plate	Minimum Upstream Straight-Pipe Diameters When Orifice Ratio $d/D =$					
	30%	40%	50%	60%	70%	80%
A. Elbow, tee, cross or reducer.	6	6	7	9	14	20
B. Two ells or two bends located in the same plane.....	8	9	10	14	18	25
C. Two fittings or two bends located at right angles to each other	16	18	20	25	31	40
D. Gate valve wide open.....	5	6	7	8	9	12
E. Globe valve, reducing valve or gate valve partially closed	19	22	25	30	38	50

d = orifice diameter; D = pipe diameter.
Where the required length of straight piping on the upstream side is not available, straightening vanes must be used.

Minimum Number of Straight Pipe Diameters Between Orifice Plate and Downstream Fittings

Type of Fitting Following Orifice Plate	Orifice Location With Regard to Downstream Fitting
A. Long radius bend....	Plate can be installed at bend inlet if no other location is available.
B. Elbow, tee or cross..	Place orifice at least three pipe diameters from fitting.
C. Gate valve wide open	Orifice plate can be installed at inlet of gate valve, provided there are at least two pipe diameters available beyond the valve.
D. Globe valve or regulating valve	Place orifice at least five pipe diameters from valve.

passage is not over 25 per cent of the internal pipe diameter. The length of the vane L should not be less than ten times the greatest dimension of any vane passage, and made substantially enough to withstand the high flow rates without breaking up.

The standard procedure is to supply the straightening vane without any tabs or flanges, but held by stops or spot welded in position to prevent its being carried along by the flowing fluid. However, there are applications, particularly in smaller size piping, where the straightening vanes are supplied in one piece, either in the form of a spool with flanges, or spot welded to a disc, which can be inserted between the existing flanges and held in position.

Pulsating Flow

A pulsating flow may be defined as a flow having periodic irregularities created by sudden and rapidly repeated changes taking place in the fluid. Such a flow is usually caused by machines having reciprocating displacement elements, in which the fluid is admitted and discharged during a portion of the stroke and is interrupted during the other portion. In such cases the flow of the fluid has regular periodical, rapid disturbances, which make its measurement one of the most difficult problems encountered in the metering of fluids.

As a rule it is almost impossible to measure such flows with any degree of accuracy. However, in some instances it becomes possible to improve conditions by reducing the effect of pulsation to a minimum.

One of the methods used to eliminate the effect of pulsation is to introduce sufficient frictional resistance in the line in order to create an extra pressure loss. This is usually obtained by means of some kind of obstruction in the pipe line between the source of pulsation and the point of measurement.

Another method consists in adding extra capacities, or volume enlargements, to the pipe between the source of pulsation and the measuring point. The best solution for many installations is a combination of throttling and additional volume.

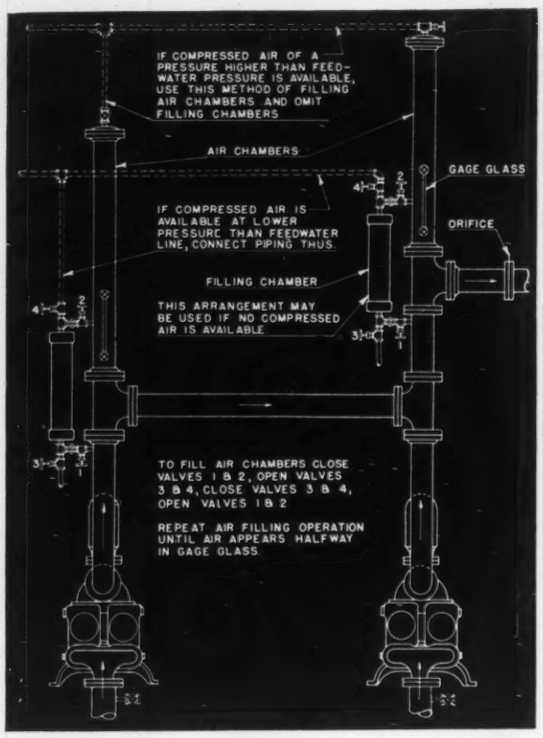

IF COMPRESSED AIR OF A PRESSURE HIGHER THAN FEEDWATER PRESSURE IS AVAILABLE, USE THIS METHOD OF FILLING AIR CHAMBERS AND OMIT FILLING CHAMBERS
AIR CHAMBERS
GAGE GLASS
ORIFICE
IF COMPRESSED AIR IS AVAILABLE AT LOWER PRESSURE THAN FEEDWATER LINE, CONNECT PIPING THUS
FILLING CHAMBER
THIS ARRANGEMENT MAY BE USED IF NO COMPRESSED AIR IS AVAILABLE
TO FILL AIR CHAMBERS CLOSE VALVES 1 & 2, OPEN VALVES 3 & 4, CLOSE VALVES 3 & 4, OPEN VALVES 1 & 2
REPEAT AIR FILLING OPERATION UNTIL AIR APPEARS HALFWAY IN GAGE GLASS

Fig. 3 — Eliminations of pulsations caused by reciprocating water pumps

The most satisfactory results are generally obtained with incompressible fluids, where the pulsations may be quieted down by the use of suitable air chambers, as shown in Fig. 3.

The method consists in installing the air chambers directly above the reciprocating pumps, and they thus act as air cushions to the flow disturbances. As a rule, better results are obtained with duplex and triplex than with simplex type pumps.

Glycerine Solves Boiler Scale Problem

The problem of boiler scale formation at one time or another confronts practically every industrial plant. To prevent or retard its formation, glycerine has been found useful, according to the *Glycerine Producers' Association.*

The boiler scale formation is caused primarily by the presence of the lime salts in the water in the boiler. The addition of glycerine acts to increase the solubility of the lime salts, forming soluble compounds.

The lime concentrations in the course of time will become too large to be assimilated in this way by the formation of soluble compounds, but as this happens a viscous, gelatine-like substance is precipitated which has the advantage of not adhering to the surface of the iron plates. Moreover, it is not carried into the cylinders of the engine by the action of the steam.

No complicated apparatus is involved in this use of glycerine to prevent scale formation, nor is it necessary to work out any complicated formula. Figuring proportionately to the amount of coal used in firing the boiler, practical experience has shown that satisfactory results are obtained simply by adding 5 lb of glycerine to the water for each ton of coal, says the Association.

In this connection a report of a recent series of authentic tests of the effect of scale in cutting efficiency is of interest. In 120 tests, 11 per cent greater output was obtained from steam engines during a single month after the boilers were freed from scale than was obtained during the three months' period before they were cleaned. When boilers are operating at heavy loads, especially, scale formation is often directly responsible for the overheating and burning out of the boiler tubes.

Restaurant Presents Peculiar Heat Gain Problem

By Lester T. Avery*

THE service area in a restaurant has a peculiar heat gain problem which must be given special consideration. The 75 seat restaurant illustrated —a long, narrow one, in the center of which is the service area—will serve as an example.

The coffee urns and steam table are hooded and provided with an adequate exhaust fan. When the cooling was originally applied, the seats near this equipment remained uncomfortably warm when the balance of the space was sufficiently cool. Originally air was distributed at both ends of the restaurant but, due to the low ceiling height, no effort was made to supply air in the center section.

One solution to the problem would be to insulate the coffee urns and steam table more thoroughly and more adequately protect with exhaust hoods to remove the source of the heat rather than to try to counteract it. However, there was little that could economically be done with the arrangement as shown. The hoods could be dropped a little, but they could not enclose the cooking equipment sufficiently to remove all of the heat generated and coffee urns and steam tables cannot be easily rebuilt to provide better insulation. (The restaurant owner who anticipates using summer air conditioning should be sure that any cooking equipment he buys is thoroughly insulated, and restaurant equipment manufacturers should emphasize the construction of their units from this standpoint.)

The solution for this particular problem was to introduce a large quantity of cooled air close to the service area; the duct shown against the beam was installed with directional and diffusing vanes to attempt to drift a large quantity of cooled air over and through the seats to offset the heating effect of the steam table and urns. At the same time special precautions were taken to prevent excessive draft. Results have been entirely satisfactory and both the owners of the restaurant and patrons are well satisfied.

Approximately 1000 cfm is delivered through the supply grille shown in the picture. The total fan capacity is 3000 cfm and the exhaust fan capacity is about 2000 cfm. There is, therefore, only enough recirculation taken from the rear of the restaurant to complete the circuit of supply and return air at all points.

In some cases the heat coming from the service area is increased with the installation of the cooling system when the effort is made to recirculate 60 or 75 per cent of the air, which prevents the exhaust fan system from removing the heat and steam directly from these cooking units. It is particularly important to be sure that ample supply air is furnished to permit sufficient exhaust over these units. In a large restaurant an entirely separate supply air system can be installed using outside unconditioned air to provide the make-up necessary for the exhaust through hoods. With the proper arrangement it is possible to short circuit this ventilation air, which

(*Concluded on page* 108)

*Avery Engineering Co., Cleveland, Ohio.

What Does Air Conditioning Mean to Industry?

I HAVE been asked by the editors to set forth what air conditioning means to industry by describing what has been achieved in various actual examples. Any one who will attempt to answer this question has far more assurance than I have; the following applications, however, are a few of the more unusual ones which have been encountered recently, and may serve to indicate the many ways in which air conditioning now is serving and will in the future continue to serve industry as an aid to industrial processing.

Food Preparation

In one remarkable food preparation process, liquid fats are emulsified by very rapid sharp cooling. The liquid pours through a slab above a large revolving steel drum, the surface of which is maintained by about 50 tons of refrigeration at something like 20 F below zero. The liquid is emulsified in a very thin sheet much after the same manner by which ice cream is frozen on a cold revolving drum, and is scraped off continuously after having traveled 90 per cent of one revolution in about two seconds. This is not a freezing process. The drum of course must be kept partly full of boiling refrigerant and the instant the warm liquid ceases to flow against the surface of the drum this surface chills far below the freezing temperature of water. Under this condition, the moisture in the surrounding air condenses upon the surface of the drum and freezes so hard that the emulsion scraper cannot remove it. The prevention of this dew deposition and its freezing becomes a very serious air conditioning matter.

It is impossible to withdraw the refrigerant from the drum quickly. If the surface of the drum were heated to prevent freezing the dew, of course there would be a tremendous waste of refrigeration and probably an explosion and wreckage of the plant would follow due to the sudden expansion of the refrigerant.

A make-shift expedient during the inevitable occasional periods during which the warm liquid for emulsification is not available is to coat the drum surface with strong brine, around 25 per cent calcium chloride, which does not freeze until diluted above its freezing point by the condensed water out of the air.

The air conditioning engineer, however, by enclosing the cold drum in an insulated and air-tight room, arranged matters so that the air within the room soon became so dry that even the low temperature drum failed to find enough water vapor in the air to condense objectionably and form ice.

Pencil Refills

The preparation of the graphite refills for magazine lead pencils involves considerations of temperature and humidity and time control. Processes must be employed in manufacturing these tiny ceramics, commencing with the paste from which they are extruded, which are a combination of those used in kiln drying lumber and those employed in burning decorative tiles and porcelains.

The filaments, which are like moulded clay, must be dried at such a slow rate and in air gradually increasing in temperature and slowly decreasing in relative humidity as will insure that the surface shall not contract and crack in consequence of the less rapid drying and shrinkage of the interior. The strength and resiliency of a properly cured pencil lead compared with the exasperating brittleness of a poorly prepared one is a matter worth noticing.

Chocolates

The rapid production of chocolate enrobed candies involves interesting applications of heating and refrigeration and ventilation. The cream centers are cast in starch moulds, just as pig iron is cast in sand moulds. The castings, having cooled and solidified, are shaken from the starch, which may be reused, just as cast metal is shaken from the moulding sand.

It is not difficult to cover the cream center by hand-dipping it into a pot of semi-liquid chocolate paste, and it is possible to smear the chocolate over the spots touched by the fingers and thus not covered in the first dipping, but the process of hand-dipping is too slow and too costly for large scale production. The first problem in machine coating of cream centers is to gain a hard chocolate bottom. Therefore the centers pass on a woven wire open mesh belt above upwardly directed jets of liquid chocolate. The bottom of each piece thus receives a coating. This thin layer of chocolate immediately thereafter is chilled by contact with a strong upward current of cold dry air. This solidifies the chocolate sufficiently to permit it to be transferred to a thin fabric belt at just the instant that the chocolate is ready to cling to the cream center and becomes willing to relinquish its less intimate hold on the woven wire.

The fabric belt passes the candy, now having a chocolate bottom but uncoated tops and edges, along a refrigerated metal table where the chocolate bottom becomes hard and smooth.

The next transfer of the candy centers is to a second open mesh wire belt, where down-coming streams of chocolate coat the tops and sides, the surplus chocolate falling through the belt for reheating and further use.

The candies with their soft tops and edges but with hard bottoms easily are transferred next to a fabric belt, usually rubber coated, though thin flexible stainless steel belts are in use. This belt is a long one, and it moves the enrobed centers through a continuous drying tunnel where streams of chilled and dehumidified air are driven

around every piece. At the departing end of the tunnel the coating is dry and hard enough to permit handling and the candy may be packed at once. The temperature of the packing room usually is maintained at about 60 F and 50 per cent relative humidity and chocolate candies never are allowed to become warmer than this until they depart from the plant. Chocolate which has been prepared for confectionery purposes quickly changes color and becomes unmarketable if allowed to become warm. It is important that the original internal heat of the cast centers shall have been extracted, as otherwise this heat will emerge into the chocolate and cause color changes even though temporarily the exterior chocolate may show a proper color.

If the powdered starch in which so many kinds of candy is cast is allowed to escape into the rooms and to settle on ducts and beams and the like, an explosive mixture of starch dust and air may be formed, even as many other organic powders are explosive when the humidity and temperature conditions are favorable. Therefore the air conditioning engineer in a candy factory employs dust conveying machinery and technique not only to reclaim the valuable starch, but also to minimize the explosion hazard.

There is practically no kind of candy made in large confectionery plants which has not, at some stage in its manufacture, been subjected to air conditioning. Air conditioning enables the lowly chewing gum to found great fortunes. Jelly beans and all day suckers owe their cheapness to refrigerated air.

Printing

The printing industry has known for many years that the same relative humidity of the air, which of course shall have had time enough to affect the paper, must be present at each of the separate color impressions in making lithographs. If the paper is dryer when the second run is made, say to apply the blue color, than it was when the red color was applied, perhaps a day or a week before, the two impressions will fail to register with one another and an unsatisfactory smearing of the whole picture will ensue.

In one large newspaper press room and paper warehouse built as an air rights structure above a railway yard, the steel girders carrying the building are imbedded partly in the press room floor. Whenever the weather outside is very cold the press room floor shows wet streaks above these girders due to the more rapid heat transfer from inside to outside through the floor above the steel than through the floor above the air. These wet spots on the floor damaged the stored print paper. The relative humidity in the press room is high, as is necessary, not only on account of lithographing but also to retard magnetism in the paper on the presses due to static electricity. The floor areas directly above the steel beams were colder than the dew point of the interior air. This state of affairs was perplexing and inexplicable until an air conditioning engineer solved the problem by installing insulation around and below the concrete encasing the steel so as to increase the dew point temperature of the floor and to insure a uniform temperature.

Steel

The steel industry might seem to the uninitiated one trade which would have little dependence on air conditioning except as pertains to the comfort of employes. However the steel industry is affected vitally because of oxidation or rusting of the product. Warehouses for storage of strip and sheet and band steel especially are susceptible to damage from rust and to staining from the presence of moisture, in whatever manner that moisture may have found its way into the piles of metal.

Following many a cold period, during which the metal may be chilled, there will be a sudden warm spell during which the warm air passing around the metal may be chilled below its dew point. This may happen in summer as well as in winter. Water literally drips from the metal, starting rust which makes new metal look old and causing stains which cannot be removed from tin plate or from galvanized sheets and which render such metals unsalable. The easiest procedure against this trouble of course is to heat the metal sufficiently that it shall always be warmer than the dew point temperature of the air.

Cosmetics

In the manufacture of cosmetics various aromatic oils and considerable alcohol are employed. A rather high relative humidity, say 55 per cent, with a comparatively low temperature never warmer than 70 F summer and winter reduces appreciably the losses due to evaporation of these materials, as well as minimizing the explosion hazard. Warm air and sufficient alcohol vapor in the presence of some means of ignition, such as an electric arc caused by a switch or motor, have been known to explode disastrously.

*Consulting Engineer, Chicago, Ill. Member of Board of Consulting and Contributing Editors.

Samuel R. Lewis* answers the question in part by citing examples of manufacturing operations that depend to considerable extent upon the air conditioning engineer

AFTER *the* FLOOD

Restoring Equipment to Service

THE evils which can follow submergence of heating, piping or air conditioning equipment in muddy water pursue a long and devious path, particularly because of the necessity of restoring service quickly after the flood has passed.

It is possible, usually, to wash out the mud from the interior of boilers, piping, tanks, pumps, etc., and thus to restore a measure of cleanliness rather rapidly. It is not possible, however, to remove the water from the brick work of boiler settings, from the windings of electric generators, motors, and electric control devices without a comparatively long drying process.

Brick work and concrete saturated with water and then heated quickly will be torn to pieces by the rapid expansion of the water and by the steam. The windings of electric apparatus must be water-free before the usual energy is applied, as otherwise the moisture will short circuit the windings and burn them out with resultant heavy expense for re-winding. Probably the best procedure is to send the armatures and coils from large motors to an electrical manufacturer's plant where they can be baked dry under controlled temperature conditions, and where they can be proved ready for service without danger of damage. Where large heavy generators have submerged it is possible to dry them out in place, using fan-blown heated air, but the process is a tedious one, and the temperature of the air must be limited.

There is some advantage in buildings liable to submergence in the use of belted small electric motors for fans, pumps, and the like, since these usually can be replaced quickly with borrowed temporary substitutes while the original motors are rehabilitated.

Of course any competent custodian will, after a flood, wash out all shaft bearings to be sure that no grit has contaminated the grease. The oil of bearings which use oil, being lighter than water, will have been replaced by dirty water, and of course this must be corrected.

There is nothing to be done about water soaked boiler masonry except to dry it out very slowly with a small fire.

If the flood came so quickly that the fires could not be drawn and the boilers cooled down, it is advisable, particularly with cast iron boilers, to apprehend cracked castings and other leaks due to the rapid localized contraction following sudden cooling by flood waters. A wise precept no matter what kind of boiler may be in service is to have a standard hydrostatic test and a complete inspection made by the boiler insurance company.

The insulation of the boiler and hot piping will almost assuredly be so compressed and matted as to be useless, if indeed it has not fallen off. The insulation depends on its cellular quality for heat-barring effect, and the cellular quality of most insulation will be destroyed when it is water-soaked. It is quite likely that even if the insulation is not ruined the canvas jackets will mildew, and that some process of sterilization of the spores and then repainting of the canvas will be necessary.

Any tanks which could not be filled when the water rose around them must have exerted a powerful lifting effect and if not torn loose may have strained the pipe connections so that they will leak. Almost any buried fuel oil tank in flooded districts will endeavor to float up with the water, especially if only partly full. It is customary to anchor such tanks with concrete of sufficient weight to hold them down, even though they are empty, and it would be wise, in preparing for a flood, to fill the fuel oil tanks full of oil and to close off the valves so that the uncontaminated oil assuredly will be on hand after the flood is over. The oil will weigh less than the water it displaces, but the oil plus the weight of the tank and that of the superimposed earth probably will overbalance the lift of the water even without a concrete anchorage.

I will never forget watching a big brick cistern floating down the Missouri River at St. Joseph, Mo., during one of the periodical floods of the "Big Muddy." This round cistern evidently was nearly empty when the river washed the earth from around it, and although it was at least 15 ft in diameter it floated along in the stream just as easily as would a jug in a bath tub.

I remember also designing a low-lying boiler room for an institution in Marietta, an Ohio City subject to floods. This boiler room is reinforced and weighted down with water-tight walls extending above flood level so that it simulates a ship's hull run aground when the high water comes.

Reprinted from an article by Samuel R. Lewis in the April, 1936, HEATING, PIPING AND AIR CONDITIONING.

Restaurant Presents—

(*Concluded from page* 105)

will permit the conditioned air to serve the public space and not be wasted through the exhaust system.

Special precaution must be taken where an exhaust system is connected in the kitchen and there is also an exhaust grille at the rear of the restaurant, as the constant opening of the kitchen door fans warm air into the restaurant, bringing with it kitchen cooking odors as well as heat. The best procedure is to block off the exhaust grille in the restaurant proper so that the exhaust fan pulls from the kitchen only, and then to provide sufficient make-up air to the restaurant to keep a pressure on the kitchen door so that whenever it opens, the air passes from the restaurant to the kitchen.

The Strength and Design of Covers and Flanges for Pressure Vessels and Piping

[Part 4]

By T. McLean Jasper*, H. Gregersen*, and A. M. Zoellner*

THE construction of a vessel or pipe line for high pressure service involves a balance in the design at every point so that the safety of such equipment can be assured. Previous investigations have established the necessity for and the required amount of reinforcement for openings in vessel walls and for the proper shapes of heads of vessels. The present investigation aims to go into the question of covers and flanges of openings. Part 1, published in November, was concerned with covers and ring flanges, and Parts 2 and 3, December and January, with hubbed flanges.

4. BOLT LOADS

In the introduction to the problem of flanges a statement was made to the effect that the bolts should be designed so that they would fail before failure would occur in the flange. The design of bolts, of course, is a matter of sound engineering judgment and experience. This part of the investigation, however, will not deal with the design of bolts but will deal with the effect of tightening various bolts and the required wrench dimensions to produce certain required bolt loads.

The bolt load equals the sum of the load due to internal pressure and the gasket load:

$$W = \frac{\pi}{4} g^2 p + G \quad \ldots\ldots\ldots\ldots\ldots\ldots [27]$$

where the gasket load G depends on the size of the gasket and the gasket pressure required for sealing. In order to assure safety, care must be taken in tightening the bolts so that the total bolt load does not exceed the value for which the flanges have been designed. In order to establish the relation between bolt load and tightening moment acting on the nut, tests have been made with bolts of various sizes and with a various number of threads per inch. The results of these tests are represented on Fig. 16 and show that the bolt load increases in direct proportion to the tightening moment. Thus, knowing the dimension of the wrench used in tightening a flange or cover and the bolt load required, the force which should be put on the wrench can be determined from Fig. 16.

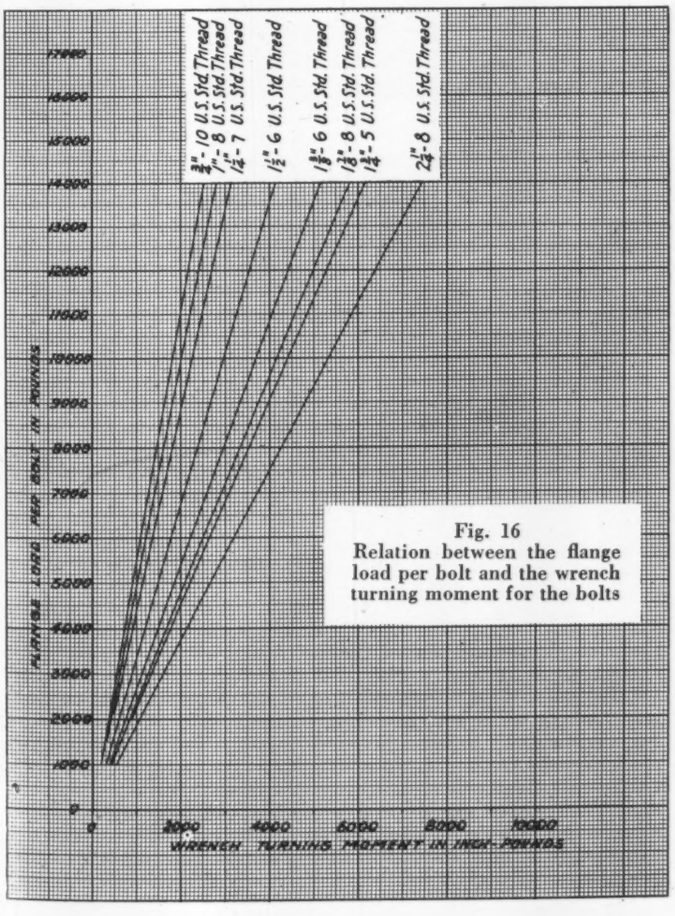


Fig. 16
Relation between the flange load per bolt and the wrench turning moment for the bolts

If a flange or cover is completely tightened before the pressure is put on, the gasket load will be equal to the bolt load. If we consider the flange or cover and the gasket material as perfectly rigid no change in the bolt load will take place as the normal pressure is put on. Since, however, the flange, cover, gasket, and the bolts are made of elastic materials, changes in the bolt load will take place as the pressure is increased.

It is believed that many engineers consider the possibility of an increase of bolt loads as the pressure is increased on the inside of a flanged and covered opening. This possibility depends on the relative elasticity of the bolts, flanges, cover, and gaskets and in order that a reliable answer to this question should be available actual tests measuring the elongation of the bolts during pressure increases were made. These measurements showed a slight decrease in the length of the bolts and incidentally in the bolt loads as the pressure was increased.

The test arrangement used in measuring the change in elongation of the bolts as the internal pressure was put on is discussed in Appendix 1.

NUMERICAL EXAMPLES

In the following a cover, a ring flange, and a hubbed flange were designed for an opening of 24 in., and an internal pressure of 750 lb per sq. in. It has been assumed that the gasket load equals one-half of the pressure load acting on the area of the gasket circle, and that the gasket load is acting on a circle with a diameter eqval to the mean diameter of the hub. For the above conditions the loads and appropriate dimensions will be as follows:

*Research Engineer, A. O. Smith Corp., Milwaukee, Wis.
Illustrations reproduced by courtesy of the A. O. Smith Corp.
This paper was presented at the annual meeting of the *American Society of Mechanical Engineers*, December, 1934, New York, N. Y., but has not heretofore been available in published form.

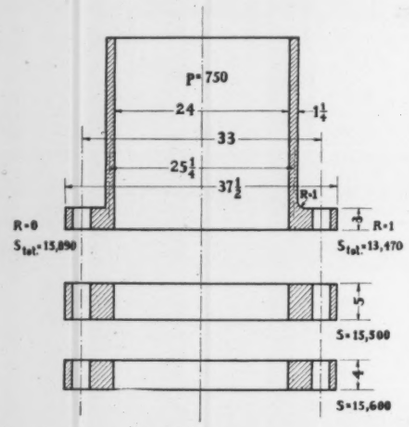


Fig. 17—Proportionate dimensions of the cover, ring flange, and hubbed flange, with the working stresses, for 24 in. opening and 750 lb pressure

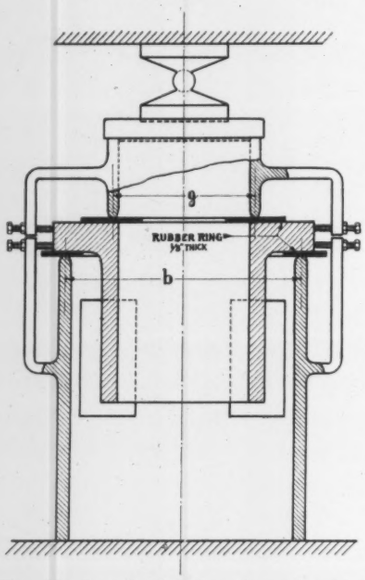


Fig. 18—Longitudinal section of equipment used in fracturing the test flanges

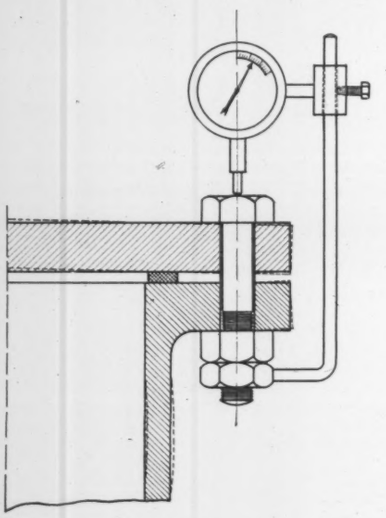


Fig. 19—Longitudinal section of hubbed flange and cover, with device for measuring change in length of bolts as internal pressure is applied

List of Symbols Used

W—Total bolt load
G—Gasket load
D—Outside diameter of cover, ring, or flange
T—Thickness of hub in a hubbed flange
S—Stress
S_r—Modulus of rupture
$M = Wa$—External moment applied or assumed in design
M_o—Moment per unit length of circumference
Q—Force
Q_o—Shearing force per unit length of circumference
M_{test}—Moment applied in test samples at failure
S_{test}—Stress obtained in test samples at failure
b—Bolt circle diameter
g—Gasket diameter
d—Inside diameter of flange or ring opening
a—Distance between gasket and bolt circle
a_o—Distance from bolt circle to center of hub thickness in a hubbed flange
d_m—Mean diameter of hub in a hubbed flange
t—Thickness of hub in a hubbed flange
μ—Poisson's ratio

$p = 750$ lb per sq in. $a = 3\frac{7}{8}$ in.
$d = 24$ in. $P = 376{,}000$ lb
$d_m = g = 25\frac{1}{4}$ in. $G = 188{,}000$ lb
$D = 37\frac{1}{2}$ in. $W = 564{,}000$ lb
$b = 33$ in. $M = 2{,}185{,}000$ in.-lb

Cover

According to the precise Formula 2a a thickness of 4 in. corresponds to a working stress of $S = 15{,}630$ lb per sq in.

Using the simple Formula 4a for plates with simply supported edge and assuming D equal to b and $T = 4$ in., this will result in a working stress of $S = 15{,}600$ lb per sq in. or approximately the same stress as obtained when using the precise formula.

Ring Flange

According to Timoshenko's Formula 8a a flange thickness $T = 5$ in. corresponds to a working stress of $S = 15{,}500$ lb per sq. in.

Hubbed Flange

Assuming a hub thickness $t = 1\frac{1}{4}$ in., and a flange thickness $T = 3$ in., and inserting the above values in Timoshenko's Formula 22 results in a maximum bending stress in the junction between ring and hub $S = 12{,}100$ lb per sq in.

The tensile stress in the junction between ring and hub can be calculated from Formula 13: $S = 3{,}790$ lb per sq in.

Thus the total working stress will be: $S_{tot} = 15{,}890$ lb per sq in.

This working stress can be considerably reduced by introducing a fillet at the junction between ring and hub. Assuming a circular fillet with $R = 1$ in. results in:

$$\frac{R}{\sqrt{td}} = 0.1825$$

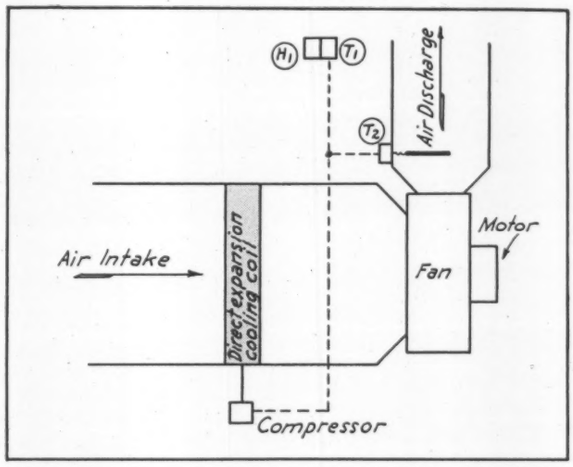
and from Fig. 8 the corresponding value of ϕ will be 0.8. Thus, according to Formula 25, the maximum bending stress in the junction between ring and hub will be $S = 9{,}680$, to which the tensile stress in the hub must be added resulting in a total working stress $S_{tot} = 13{,}470$ lb per sq in. Thus the introduction of a circular fillet with $R = 1$ in. results in a 15¼ per cent decrease in the total working stress which can be said to be

[*Concluded on page* 112]

CONTROLS

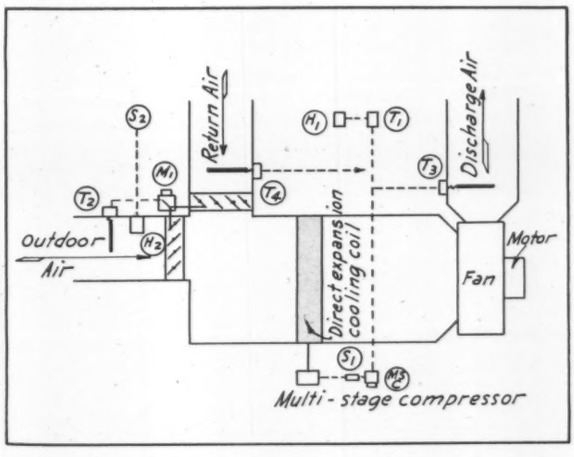
By C. L. Ringquist*
Reference Sheet 6

Cooling, Ventilating and Dehumidifying Systems



Cycle—Combination room thermostat and humidistat noted as H_1 and T_1 controls the action of a cold water modulating motorized or diaphragm operated valve in the return or discharge line from the cooling coil. Thus, whenever either the temperature or humidity exceeds the setting of the thermostat or humidistat the valve will be opened, allowing more water to flow through the coil. Duct thermostat T_2 in the discharge air from the fan acts as a limit controller to prevent the system from discharging alternately cold and warm blasts of air. This thermostat always maintains the air leaving the fan a definite number of degrees below room temperature.

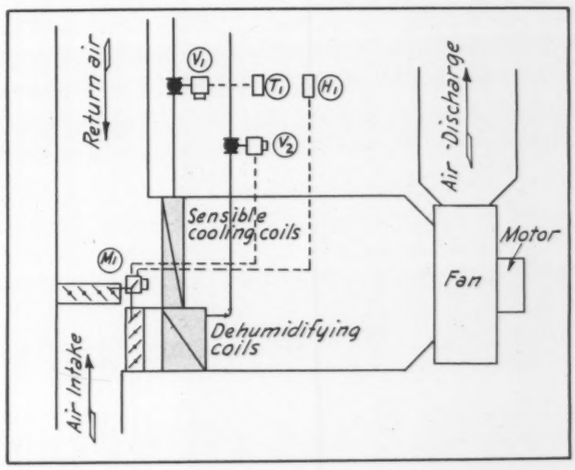
An effort is made in the design of the following system to conserve on operating expense and proportion amount of cooling supplied to meet load requirements:



Cycle—Room humidistat H_1 (in conjunction with room thermostat T_1, or as an alternate a return air duct thermostat T_4) acts to control amount of cooling supplied to the coil by controlling the amount of coil surface supplied with refrigeration, this action taking place by means of multiple step controller S_1. In addition, duct thermostat T_3 acts to maintain a definite outlet temperature from the fan by taking control of the refrigeration supplied to the coil when T_1 and H_1 are satisfied.

The other controls consist of a set of outside air and recirculated air dampers controlled by damper motor M_1 from the duct thermostat T_2 and humidistat H_2. The thermostat T_2 acts to open the outside air damper and close the recirculated air damper when the outside air temperature drops within a set temperature range. Humidistat H_2 measures the humidity in the incoming outside air and controls the outside air damper so that it cannot open beyond a minimum setting unless the humidity of the outside air is below a definite setting as determined by hand switch S_2.

The systems so far described have made very little attempt if any to control the temperature and humidity separately. In the following system, the temperature and humidity are controlled independently:



Cycle—Room humidistat H_1 controls amount of outside air passing through dehumidifying coils by means of dampers and modulating damper motor M_1, which is equipped with an auxiliary switch so that when face damper in front of dehumidifying coil is entirely closed refrigeration is shut off for the dehumidifying coil by means of motor or diaphragm valve V_2, which is of modulating type. Room thermostat T_1 controls modulating

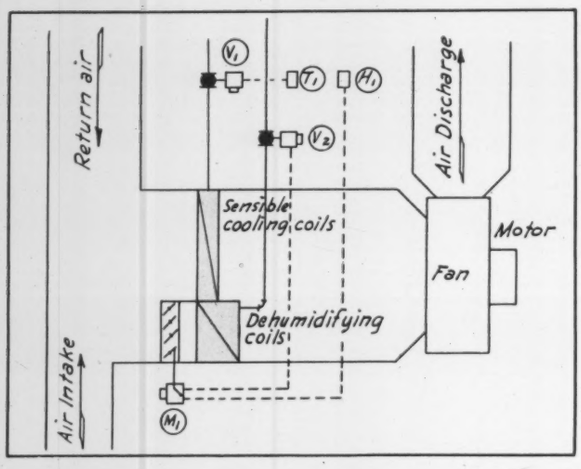
*Air Conditioning Department, The Trane Co., La Crosse, Wis.

Although data on automatic controls for heating, humidifying, dehumidifying, ventilating, cooling and complete air conditioning may be had from numerous sources, information on groups of controls applicable to various types of systems is not so readily available. The author has therefore diagrammed typical control layouts, with each of which is given an explanation of the control cycle. . . For the purpose of illustration, central fan coil types of systems are used; the control arrangements described are equally applicable to units built up to perform the same functions. . . Types of systems covered by this series include humidifying; ventilating; heating and ventilating; heating, ventilating and humidifying; cooling, dehumidifying and ventilating; cooling, dehumidifying, ventilating and humidifying; heating, ventilating, dehumidifying and cooling; heating, ventilating, dehumidifying, cooling and humidifying; and zone control systems.

type motor or diaphragm valve V_1 to control temperature of air leaving the sensible cooling coils in accord with amount of cooling required in the conditioned space.

Thus the air conditions leaving the coils can be controlled within limits determined by the coil design and selection.

Occasionally, the outside air requirements of a system are such that if a design like that just described were used, the leaving air from the dehumidifying coils would be such that it would mean unnecessarily large equipment or an extremely low temperature refrigerant in the dehumidifying coils. In order to overcome this a system of the following type may be used:



Cycle—The controls operate in the same manner as in the preceding example in that the dehumidifying is controlled by humidistat H_1 and the amount of air passing through the dehumidifying coils. The temperature is controlled by the room thermostat and modulating valve V_1.

Strength and Design of Flanges—

[*Concluded from page* 110]

quite considerable when compared with the small amount of metal added.

The proportionate dimensions of the cover, ring flange, and hubbed flange are shown in Fig. 17, with the working stresses.

Fig. 20—Flange suspended in loading equipment

APPENDIX 1—TEST ARRANGEMENT

A longitudinal section of the general loading equipment used in fracturing the test flanges is shown in Fig. 18. As can be seen the flanges were suspended between two cylinders, the lower one transmitting the bolt load and the upper one transmitting the gasket load. In order to assure uniformly distributed load, rubber rings were placed between the two cylinders and the flange, and a ball and socket joint was introduced between the upper cylinder and the testing machine. In order to assure concentric loading each of the two load transmitting cylinders

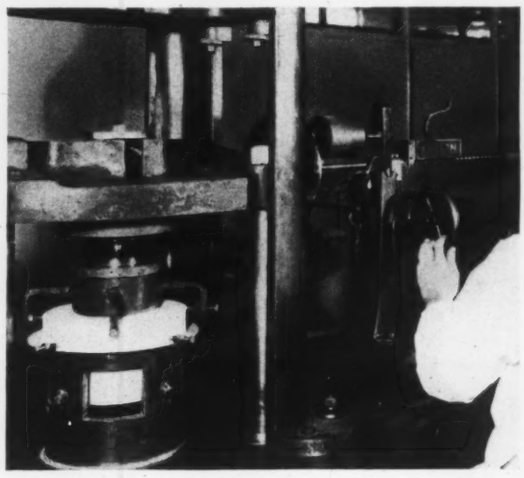


Fig. 21—Arrangement of flange and loading equipment in testing machine

was provided with four radial arms with adjusting screws. A slight clearance between these adjusting screws and the flange was necessary in order to prevent the flange from touching the screws, due to the deflection caused by the load. Fig. 20 shows a hubbed flange suspended in the loading equipment, and Fig. 21 shows the total arrangement of flange and loading equipment in the testing machine.

A longitudinal section of a hubbed flange and cover with the device for measuring the change in the length of the bolts as the internal pressure is put on is shown schematically in Fig. 19. The dotted lines indicate the additional deflection of flange and cover due to the internal pressure. Due to this additional deflection the elongation of the bolts decreases, whereby the bolt load diminishes correspondingly.

[*To be continued*]

More Cities Report A. C. Installations

The following figures supplement the review published last month of air conditioning installations made during 1936 in cities with a total population of over 30,000,000:

Louisiana, New Orleans—86 installations totalling 1577 hp made during 1936. In 1935 there were 68 installations totalling 2482 hp.

Minnesota, Minneapolis—103 installations totalling 519 hp, 67 of which totalling 338 hp use mechanical refrigeration and 36 totalling 181 hp use deep well or city water.

Minnesota, St. Paul—49 installations totalling 218 hp, 37 of which totalling 185 hp use mechanical refrigeration and 12 totalling 33 hp use deep well or city water.

New Jersey, Newark—82 comfort summer air conditioning installations using mechanical refrigeration made during first 11 months, totalling 1482.2 hp.

Texas, Houston—89 installations totalling 1388.8 hp.

Heating·Piping
and Air Conditioning

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS

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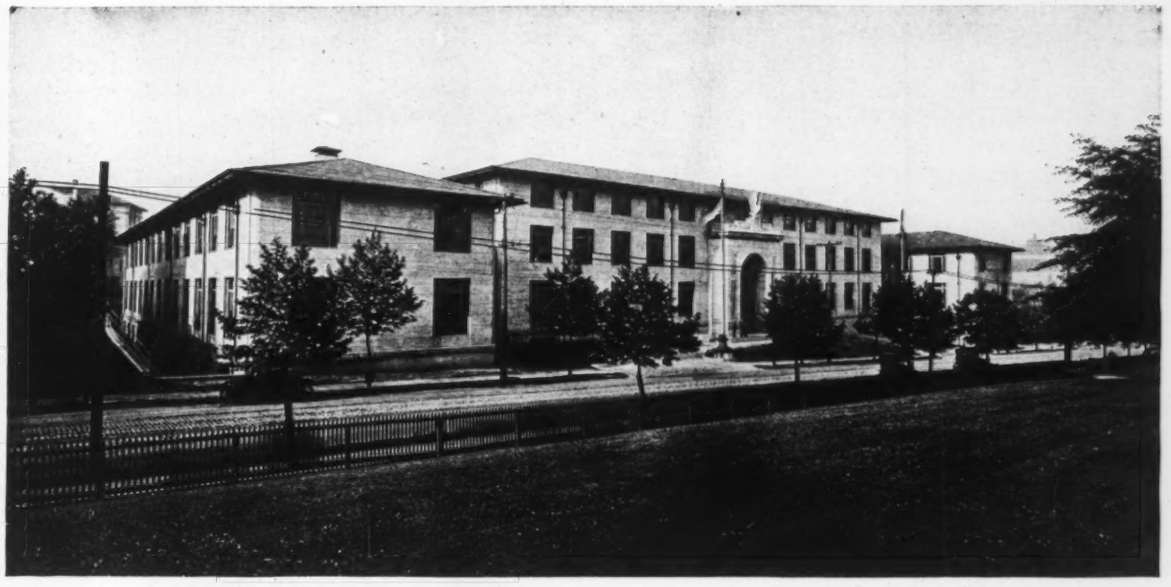

Pittsburgh Experiment Station of the U. S. Bureau of Mines where the Research Laboratory of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS is located

Fever Therapy Induced by Conditioned Air

By F. C. Houghten* (*MEMBER*), M. B. Ferderber, M. D.** and Carl Gutberlet *** (*NON-MEMBERS*)

Pittsburgh, Pa.

IT is recognized that the recent increase in longevity has resulted, in some measure, from sanitation applied to sewage disposal and the care of food, thus lessening the hazards of infection in the digestive tract. There is reason to believe that a similar extension may result in the future through similar sanitary applications to the atmospheric environment, or air conditioning.

Certainly when the human body is considered as a prime mover taking in food and air to be oxidized in the transformation of energy to be expended in physical activity, and in maintaining the required limits in body temperature under widely varying environmental conditions, it would appear that the control of this environment in order to lessen extremes in adaptation is desirable. No engineer attempting to control the temperature of any device or material in the process of heat treatment, where even a relatively large margin of temperature variation is permissible, would consider for a minute allowing the temperature of the environmental air to fluctuate at will over wide limits. Yet in disease little attention is paid to the environmental air to which body heat must be dissipated, even when disease most violently upsets the temperature control mechanism of the body. It is logical to believe that in many, if not all, human ailments the patient would react best under some optimum atmospheric surroundings. What air conditions should constitute these surroundings in any given case is not even suggested at this time, but the establishment of the particular conditions under which any given disease might react most favorably should not be difficult to determine, if once the air conditioning engineer and the medical man cooperate in studying the problem.

It has recently developed that certain diseases, including syphilis and gonorrhea, react favorably to an elevated body temperature. This was first observed when patients suffering one of these ailments contracted typhoid fever, and as a result were apparently cured of the social disease. Experimentation indicated that the rise in body temperature resulting from the fever produced the desired effect, and as a result artificially induced malaria fever has been resorted to as a cure.

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Presented at the 43rd Annual Meeting of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, St. Louis, Mo., January, 1937.

It has since been reasoned that if the rise in body temperature resulting from malaria fever is in itself the primary condition resulting in the cure, then other means for elevating the body temperature could more satisfactorily be used. Diathermy, or the raising of the temperature of the tissues of the body through the application of radio-magnetic waves within the body itself, has been used with some success. More recently, other means of elevating the body temperature of the patient have been used.

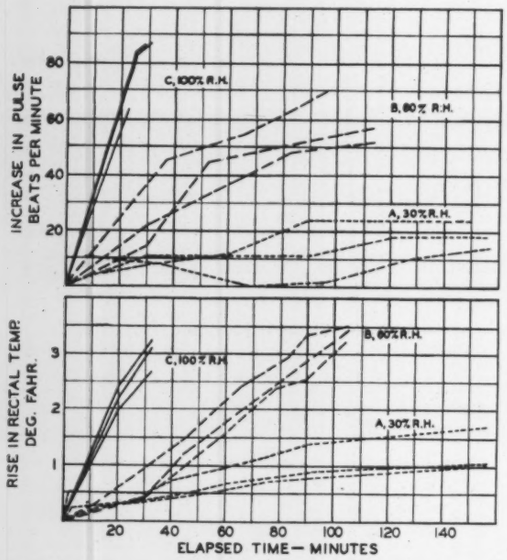

Fig. 1—Relation between rise in body temperature and increase in pulse rate for three normal persons after entering an atmosphere of 112 F and 30, 60, and 100 per cent relative humidities

In 1929, a group of physicians and engineers, discussing the problem at the Research Laboratory of the American Society of Heating and Ventilating Engineers, agreed that probably the most satisfactory means of uniformly elevating the body temperature without undue hazard and discomfort was through a proper control of the temperature and humidity of the environmental atmosphere. During the period from 1920 to 1929, studies[1] were conducted by the Research Laboratory of the American Society of Heating and Ventilating Engineers, in cooperation with the U. S. Public Health Service and with the U. S. Bureau of Mines at Pittsburgh, to determine the physiological reactions of men working in the high temperatures required in some industries. These studies established many facts regarding the rise in body temperature, increase in pulse rate, and other physiological reactions of such persons. As a result, there was made available a comprehensive record of physiological reactions of persons over a very wide range of relative humidity, temperature and air movement, including a range of temperature from the upper limits of the Comfort Zone to high temperature conditions in which life could not continue for more than one hour. From these records it is a simple matter to determine suitable combinations of temperature and humidity in either still or moving air to give any desired rate of rise in body temperature. Fig. 1, taken from these records, shows the rate of rise in body temperature and the increase in pulse rate of three normal men in an atmosphere of 112 F, and with 100 per cent, 60 per cent, 30 per cent relative humidity. It will be noted that with 30 per cent relative humidity this high temperature results in a relatively small change in pulse rate and body temperature, while a saturated atmosphere with the same temperature gives rapid changes.

Following the first conference on the subject of fever therapy at the Research Laboratory, Dr. H. W. Wuerthele and the members of the Laboratory Staff agreed in March 1929 to the treatment of two cerebro-spinal syphilitic patients in the psychrometric rooms of the Research Laboratory. A series of fever treatments resulted in satisfactory improvements, demonstrating conclusively the feasibility of the application of air conditioning in the elevation of body temperature.

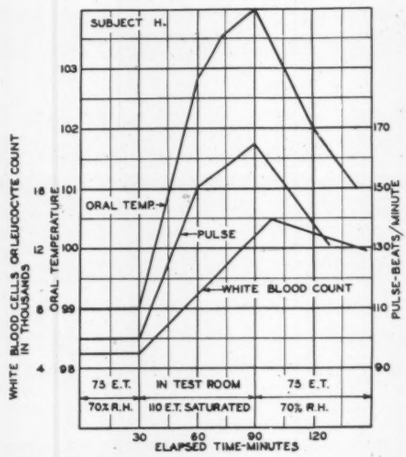

Fig. 2—Rise in body temperature, change in pulse rate and change in leucocyte (white blood) count, during exposure to an atmospheric condition of 110 dry-bulb, and 100 per cent relative humidity

Early in 1935 another conference on the subject resulted in agreement that the best method of treating such cases was not in a large room, where several patients could be handled, but in a small box, where a single patient could be treated in a hospital under the control of the physician and nurse. Another question considered during this conference was whether the high temperature to which the disease organism is subjected

[1]Body Temperatures and Their Measurements, by W. J. McConnell, M.D. and F. C. Houghten, A.S.H.V.E., Transactions, Vol. 28, 1922, p. 211.
Some Physiological Reactions of High Temperatures and Humidities, by W. J. McConnell, M.D., and F. C. Houghten. A.S.H.V.E. Transactions, Vol. 29, 1923, p. 122.
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Heat and Moisture Losses from the Human Body and Their Relation to Air Conditioning Problems, by F. C. Houghten, W. W. Teague, W. E. Miller and W. P. Yant, A.S.H.V.E. Transactions, Vol. 35, 1929, p. 245.
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Thermal Exchanges Between the Human Body and Its Atmospheric Environment, by F. C. Houghten, W. W. Teague, W. E. Miller and W. P. Yant, *The American Journal of Physiology*, Vol. 88, No. 3, April, 1929.
Thermal Exchanges Between the Bodies of Men Working and the Atmospheric Environment, by F. C. Houghten, W. W. Teague, W. E. Miller and W. P. Yant, *American Journal of Hygiene*, Vol. XIII, No. 2, March, 1931, p. 415.

in fever therapy is the primary and only factor in its destruction, or whether the rise in body temperature might not be accompanied by an increase, in the leucocyte count of the blood. Such an increase in the leucocyte count might be either the real cause of the cure, or a secondary factor. The earlier work at the Laboratory in cooperation with the U. S. Public Health Service had not revealed any consistent change in the leucocyte count of the blood.

A series of tests was planned and carried out in 1935 in the psychrometric rooms of the Research Laboratory, in cooperation with physicians of the St. Francis Hospital. In these tests five persons offered themselves as subjects and were placed in saturated atmospheres of 105 and 110 F. In all but one of these cases, a phenomenal increase in the leucocyte count of the blood paralleled the rise in body temperature, indicating that the increase in the leucocyte count might be an important factor in the application of fever therapy. The relation between the hot condition, elapsed time and rise in body temperature, increase in pulse and increase in leucocyte count for two of the subjects are given in Figs. 2 and 3. The negative case, showing no material rise in leucocyte count, was a person of rather low vitality, who suffered unusual discomfort from the high temperature, and who collapsed when his body temperature reached 102 F. While this case proves nothing, it serves to indicate possibilities for further research.

After an analysis of the available data, in the files of the Research Laboratory, on the relation of rise of body temperature to the discomfort of persons subjected to hot atmospheres with different humidities, it was agreed that a most satisfactory box condition for giving fever therapy would be a saturated atmosphere. This would give a rapid rise in body temperature with a relatively low dry-bulb temperature of the air and a similar low temperature of all surfaces and objects in or around the box which might come in contact with the patient. Further, it appeared from the experience gained in the earlier studies that less discomfort resulted from a given rise in body temperature in a hot atmosphere with a high rather than a low relative humidity. Accordingly, a careful study of the various possibilities in design which would give these conditions resulted in the box shown in

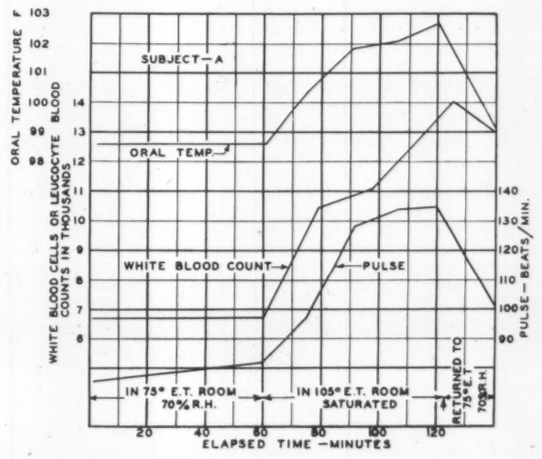
ORAL TEMPERATURE F
WHITE BLOOD CELLS OR LEUCOCYTE COUNTS IN THOUSANDS
PULSE — BEATS/MIN.
SUBJECT — A
ORAL TEMP.
WHITE BLOOD COUNT
PULSE
IN 75° E.T. ROOM 70% R.H.
IN 105° E.T. ROOM SATURATED
RETURNED TO 75° E.T. 70% R.H.
ELAPSED TIME — MINUTES

Fig. 3—Rise in body temperature, change in pulse rate and change in leucocyte (white blood) count, during exposure to an atmospheric condition of 110 dry-bulb, and 100 per cent relative humidity

Fig. 4. A drawing of the box, showing diagrammatically the arrangement of the air conditioning apparatus, is illustrated in Fig. 5.

The high temperature water spray serves to elevate the temperature and moisture content of the air, and also to circulate it through the system. The slight drop in air temperature from the point where it leaves the water spray to the box insures saturation in the box at all times when the spray is running. The water spray gives sufficient air velocity in the 6-in. duct to give a 115 cfm air supply, or 2½ air changes in the box every minute. The high temperature, humid air supplied at the top, and rapidly removed at the bottom, gives a very uniform air temperature throughout any horizontal cross-section of the box, and a temperature gradient from top to bottom of no more than 2 deg. The fact that neither a heater nor any other object or surface is ever found in the box at a higher temperature than the circulating air insures against burns from any imaginable accident or carelessness in operation. Since saturated air even at a considerably higher temperature than that used will cause no damage or disturbance other than an increase in the rate of rise in body temperature, there need be no fear of harmful effects from this source.

Essentially, the air conditioning equipment is extremely simple and of the dewpoint control type. Any source of hot water will serve the purpose equally well. In the experimental studies at St. Francis Hospital, thus far conducted, tap water from the hot water supply service was used, thus requiring no heater or mechanically moving parts in the entire equipment. The fact that this service could be supplied most easily by the hospital seemed to justify its use, although from an engineering point of view the practice would be recognized as wasteful of both water and heat. In later use of the box, a pump has been applied for recirculating the water through an electrical heater. Either a gas-fired heater or steam heat exchanger would serve equally well. It has been found desirable to add a small amount of fresh water to keep down odors in the box.

Proper control of the air temperature in the box and of the body temperature of the patient requires ample facilities for control. Complete control may be had either by temperature indicating, or better, temperature recording instruments, giving the hot water temperature at the spray, the air temperature in the box, and the rectal or oral temperature of the patient. Suitable instruments of either the indicating or recording type are available for any of these purposes. In the experimental work thus far carried on, copper-constantan thermocouples used with a precision potentiometer and mercury thermometers have been found more serviceable.

The patient is placed on the sponge rubber mattress and pushed into the box in a room at a slightly elevated temperature. The hot water spray is then turned on. Fig. 6 shows the rise in the spray water temperature and the resulting box temperature on a trial run with no patient in the box and when the hot water supply was at 130 F. A very satisfactory operation of the box with a patient in it is as follows: After the patient is in the box, the hot water is turned on and the box temperature raised to 120 F. Under favorable circumstances, this can be done in 3 min. The box temperature may then be kept at 120 F for about one-half hour, during which time

Fig. 4 — Air conditioned fever therapy box in operation

the patient's temperature may be expected to rise from normal to 104 F. The box temperature is then dropped to 110 F for an additional 20 min, which may be expected to bring the patient's temperature up to 106 F. If this is the degree of fever predetermined for the particular patient the box temperature is dropped to a temperature between 100 to 103 F, so as to maintain the patient's body temperature at 106 F. After the patient's temperature has reached the desired level, a lower air temperature in the box is required, due to the fact that the patient himself is generating in the neighborhood of 400 Btu of heat per hour, which, in order not to raise his body temperature further, must be dissipated to the atmosphere in the box.

It is not the aim of the authors to present a complete professional record of the treatment of patients in this engineering report. It is hoped that such a record will be published in the medical press. However, the following brief discussion of the subject may be of interest.

The clinical application of fever therapy induced by air conditioning to the treatment of disease has been both interesting and satisfactory in most cases. Up to this time, 70 patients have been treated. Gonorrhea, one of the most common of venereal diseases, has been treated in almost all of its phases. The organism, Neisseria Gonorrhoeae, has a thermal death point between 106 and 107 F in vitro, but workers previously have shown that if the patient's temperature is elevated between these points, the organism is destroyed similarly. In addition to this, elevating the temperature stimulates the body in such a way that the white blood corpuscles are increased in number. These act as scavengers, which clean up debris and inflammatory material left by the infection

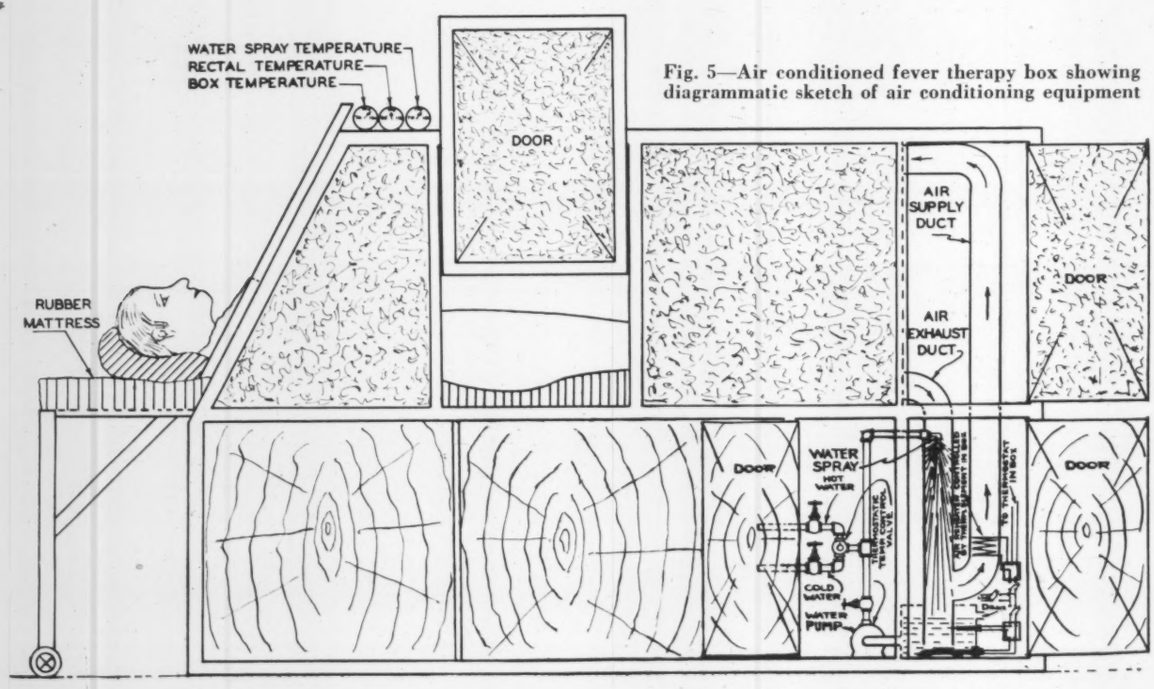

Fig. 5—Air conditioned fever therapy box showing diagrammatic sketch of air conditioning equipment

caused by the organism. This is especially true in females with gonorrhea, who complain very bitterly of severe pain in the lower abdomen. Because of the peculiar structure of the female pelvis and the location of the organs, there are many areas which become filled with this inflammatory material, binding down the organs in such a way that pain always occurs. It is very gratifying to see these patients get relief even after one treatment of about one to three hours, and with a full course of treatment their pain recedes and does not recur unless they become re-infected.

In the male, the relief of urethral symptoms such as pain, burning, etc., is rapid with Fever Therapy. The use of this type of treatment prevents complications which leave their stigmata in the male. However, in both sexes arthritis caused by gonorrhea can be treated with fever therapy *specifically*. If treated early, there is no joint disability, and the patient is restored to usefulness. In chronic cases where some joint destruction has occurred, fever therapy frequently aids in restoring some function to the involved joint. When the excruciating pain of these arthritics and the striking relief obtained with fever therapy are observed, it is difficult to be skeptical about its usefulness. As in any other acute disease, the sooner treatment is instituted, the more gratifying are the results. Experience indicates that 12 to 25 hours are required to clean up this infection with sessions of 3 to 5 hours duration given at 3 to 7 day intervals.

In syphilis the situation is entirely different. The organism Treponema pallidum attacks certain organs of the body, namely, the circulatory system (heart, blood vessels) and the central nervous system. In the latter connection, the brain is so attacked that various degrees of insanity and other cerebral manifestations result. The term paresis is applied to this ailment and it has very frequently been called *Insanity of Syphilis*. It is a degenerative disease with mental deterioration resulting in peculiar behavior on the part of the individual. There are many other manifestations of this disease in the nervous system, which are not discussed in detail in this paper.

Fever therapy arrests this degenerative process in a great majority of cases and frequently restores its victim to usefulness. Since the thermal death point of the organism varies from 103 to 106 F, it has been the practice in this study to maintain the patient's temperature at about 105 to 106 F. Malarial inoculation to produce fever has been in use for years. It is felt as a result of this study that artificial fever has the additional advantage of being safer to handle without imposing one disease on another. It is hoped further study will show the relative ease of artificial fever administration as compared to malarial inoculation in cases of syphilis. The other manifestations of this disease may be treated with fever together with the various chemicals, and good results have been reported. The combination of fever therapy and drug is very useful because the drug is disseminated more thoroughly through the tissues because of its easy passage through the blood vessels dilated by the fever. In paresis about 25 to 50 hours produce the best results with 5 hour sessions given every week.

In Chorea, or St. Vitus' Dance, fever therapy has done much to bring about recovery and shorten the course of the disease. Even after the first treatment, the purposeless, involuntary movements abate and frequently cease. Eight or nine sessions at 105 to 106 for 3 to 4 hours are suggested in these cases. Since this particular disease has been treated more recently, there is not much data available on just how the method works. Some time in the future more may be written on this subject.

In this study fever therapy has been tried in multiple sclerosis, a degenerative disease of the central nervous system, without striking results, although other workers' reports are encouraging.

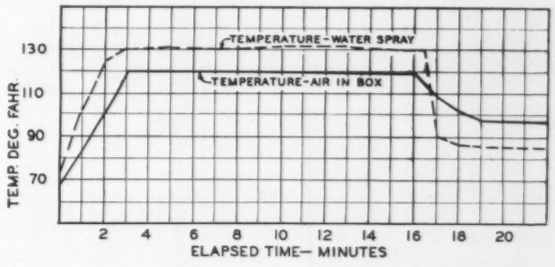

Fig. 6—Relation between spray water and box temperature after valve controlling 130 F water was turned on*
*Ave. spray water consumption 30 gal per hour. Ave. air supply 115 cfm or approx. 2½ air changes per minute.

There has been some success with one case of Parkinson's Syndrome, a manifestation of encephalitis. This patient had a tremor of the right hand for 9 years and was unable to earn his living, but after 25 hours of fever between 105 and 106 F, this tremor has ceased, and he is now actively engaged in making a living. However, this single case proves nothing, but must be amplified by more cases which are now being studied.

Before accepting any case for fever, a case history is taken, the patient is carefully examined, especially for a weak heart, high blood pressure, or hardened arteries, all of which are contraindications to giving fever. Patients who are weakened and debilitated do not receive treatment. The blood counts, as well as bacteriological studies, are made before starting the procedure. A sedative is administered, and while lying in the box, the face and head are cooled both by an electric fan, and ice applied directly. This gives some degree of comfort to the patient and minimizes the danger of delirium. Since the chloride and fluid loss is great, 0.6 saline solution is given by mouth. Rectal temperatures, pulse and respiratory rates are taken every 10 min and blood pressure readings are made at greater intervals. The pressure is at first elevated and drops down as dilatation of the vessels takes place. No covers are used on the patient during treatment, thus permitting freedom of movement at all times. If the patient becomes restless, a small dose of opiate is administered. After the fever has been given, the patient is put to bed, and glucose and saline solution, which are given by vein, act as a stimulant and food, especially since the patient has eaten nothing prior to and during his treatment. Many patients come in the morning, have treatment, sleep a few hours following treatment, and leave the hospital in the evening without any difficulty whatsoever. Occasionally some individuals develop herpes (fever blisters) on the lips which at times become troublesome, but little can be done about it. The

complication of fever delirium rarely occurs. Cyanosis occurs infrequently but the administration of O_2 (90 per cent) and CO_2 (10 per cent) clears this up immediately and the treatment goes on. There have been no burns in this cabinet, and it is felt that this is quite a remarkable record when it is considered that these patients have no covering except a very short gown worn for modesty's sake. The following case records may be of interest.

A girl, 18 years old, was forced to leave high school in her senior year because of mental changes and some difficulty with her vision. She was referred to a well-known neuro-psychiatrist in Pittsburgh, and sent to the hospital. Laboratory data revealed the fact that she was suffering from congenital (hereditary) syphilis. Malarial inoculation was given to induce a fever, but nothing favorable resulted. Artificial fever in the Laboratory's box was then tried as the first case in this study.

After 12 hours of fever, varying from 105 to 106 F, her eye findings were greatly improved and her mutterings and mental aberrations ceased. Her responses were normal in every respect. She was discharged from the hospital, and has since returned to school and completed her studies.

An 18 year old colored male was carried into the hospital suffering from excruciating pains in the left ankle, knee, elbow, wrist and joints of the hand. Also affected were the right knee, elbow, wrist and hand. There was also a urethral discharge which upon laboratory diagnosis was revealed as gonorrheal. He was exposed to the infection 5 days before admission and the pain began 2 days before admission. Morphine was required to ease the pain and he was unable to use his hands and had to be fed. Fever was begun the next day, with the temperature between 106 and 107 F, for a 4 hour period. It must be remembered that this occurred during the extremely hot weather of July. After the first session, he was able to sleep without the aid of opiates and could handle his food. The treatments were repeated every 3 or 4 days and after 20 hours he was entirely clear of pain, upon either active or passive motion. At the same time the urethral discharge ceased and he was no longer kept in isolation. Three days later he was discharged from the hospital, and during the week of September 24, 1936 a complete fixation test (diagnostic test using patient's blood) was negative. Before treatment it was positive. In sharp contrast to this case was that of a young adult admitted to the hospital last winter with the same ailment only in two joints, the hip and knee. Without using fever, he remained in the hospital for 128 days, receiving such treatment as vaccines, diathermy and a cast on his body. The first case cited was in the hospital only 17 days. Since both were free cases, it is obvious that a great economic saving is possible with this form of treatment.

A 25 year old woman was exposed to gonorrhea and was brought to the hospital complaining of severe pain in the lower portion of the abdomen. Although a tentative diagnosis of appendicitis was made, the history, along with the laboratory findings, definitely indicated gonorrheal salpyngitis (fallopian tube inflammation). Fever was given between 106 and 107 F for a total of 18 hours, resulting in complete subsidence of pain and other symptoms. It is interesting to note that this patient could not rest at night because of the severe pain in the abdomen, and opiates were necessary to give the patient some measure of relief. In this instance, as in others, the acute pain subsided after the first treatment of 3½ hours, and the patient was able to sleep without the use of sedatives or opiates. This patient, however, developed herpes (fever sores) on her lower lip, which retarded treatment for 5 days. However, treatment was resumed, and before discharge from the hospital, a vaginal examination revealed no pain or discomfort; nor were there any signs of abnormal changes in the pelvic organs. This latter complication frequently occurs if the condition is untreated, and an operation is the usual sequel in time. Hence, early treatment is desirable.

Acknowledgment

The authors wish to acknowledge the valuable aid rendered by: Dr. W. H. Wuerthele, whose interest in the possibilities of fever therapy, and whose foresight in recognizing the possibilities of applying air conditioning to the problem, originally encouraged the authors to undertake the study on the present basis; Sister M. Thomasine, Superintendent, and her staff of St. Francis Hospital, in making available the many facilities necessary for the study; Dr. A. W. Sherrill, Associate Professor of Medicine, University of Pittsburgh, and head of the Department of Physical Therapy at St. Francis, in whose department the work was carried on, for his systematic cooperation; M. J. McCarthy, Chief Engineer, who supplied the many mechanical facilities necessary for the successful operation of the box in the hospital; Miss Gertrude Demsko, R.N., who was constantly with the patients treated, and whose untiring efforts even after hours was a large factor in the success of the study.

A.S.A. Announces Standard Acoustical Terminology

According to an announcement of the *American Standards Association*, a standard Acoustical Terminology for sound engineers which will eliminate confusion in movie, radio, and building fields has recently been completed. This standard is the result of engineers, musicians, manufacturers, and scientists working together under the auspices of the *A.S.A.*, which served as a clearing house for standardization.

The committee has given a broader meaning to the word *noise*, now defined in terms of the listener as an *unwanted sound* rather than in terms of the sound itself. A section of the standard deals with architectural acoustics, while another provides standard terms for the measurement of hearing and will be used widely by the medical profession and by manufacturers of aids for the partially deaf. Other parts dealing with the conversion of sound to electrical energy and with acoustic transmission systems will be of particular value to the movie and radio professions. A separate section for music brings engineers and acoustical experts into agreement with musicians on a basic standard pitch.

A Rational Method of Duct Design

By L. G. Miller* (*MEMBER*) East Lansing, Mich.

ANYTHING rational has *reason or understanding* according to Noah Webster. The following method of duct design is presented because each step is a result of reasoning. This outline is intended to serve only as a guide for the method. No claim is made for the accuracy of the data, but it is hoped that those having data known to be authentic will present it and that properly equipped laboratories will supply that information needed to satisfy controversial views.

Before the problem of air duct design can be approached, such items as design and location of grilles, quantity and quality of air to be circulated, and the location of the fan and conditioning apparatus will have been determined by engineering calculations and estimates. An illustrative problem is interspersed throughout the discussion of the method. The results of the engineering calculations as they apply are included in Table 1.

Table 1—Residential Air Quantities Required

Room	Grille No.	Cfm	Delivered Velocity Fpm
Living Room 1	1	95	500
Living Room 2	2	95	500
Dining Room	3	100	425
Sun Room 1	4	145	300
Sun Room 2	5	145	300
Kitchen	6	60	300
Hall Down	8	100	300
N. W. Bedroom	9	130	500
S. W. Bedroom	10	100	400
N. E. Bedroom	11	125	500
S. E. Bedroom	12	115	300
Hall Up	13	50	100
Bath	14	45	200
Recreation 1	25	125	100
Recreation 2	26	125	100

Design of Duct System

The first step in actual design of a duct system is to connect the grilles with the fan and other apparatus into a workable closed system. It is hardly necessary to state that the plans, or actual structure, must be thoroughly inspected for structural details that might hinder or aid in erecting the duct system. Economy of construction and of operation, two diametrically opposed considerations, should be weighed one against the other. In order to facilitate such studies it seems desirable to add to the Symbols for Heating, Ventilating and Air Conditioning Drawings given in Chapter 44 of The Guide 1937 some items commonly encountered in duct layout. A partial list appears in Fig. 1. Using these symbols, sketch on the plan involved, a line layout. Such a sketch for the flow ducts in a residence is illustrated by Fig. 2.

*Head, Dept. of Mech. Engrg., Michigan State College.
Presented at the 43rd Annual Meeting of the American Society of Heating and Ventilating Engineers, St. Louis, Mo., January, 1937.

Selection of Design Branch Duct

Select by inspection the duct appearing to have the least unavoidable resistance and design it for the highest usable velocity. Outlet No. 4 of Fig. 2, requiring that 145 cfm be delivered from the grille at 300 fpm velocity, is selected because it is the shortest run and appears to have little natural resistance. Some work is being done, to reduce noise generation and transmission by the duct systems. Findings to date with more definite recommendation should be published in subsequent editions of The Guide to allow higher velocities and resultant smaller ducts. Based upon data given in The Guide 1937, the highest velocity which should be used in this vertical wall stack is 750 fpm and in the branch horizontal duct 1000 fpm. The cross-sectional area of these sections would therefore be $\frac{145}{750} = 0.193$ sq ft $= 27$ sq in. and $\frac{145}{1000} = 0.145$ sq ft $= 22$ sq in. A 3 x 9 in. wall stack, having a cross sectional area of 27 sq in. would be right. The table given on p. 372 of The Guide 1937, Circular Equivalents of Rectangular Ducts for Equal Friction should be extended to include at least 3 and 3½ in. dimensions to accommodate designers of residential heating. The equivalent of a 3 x 9 in. duct is 5.5 in. One dimension of a trunk line system is usually determined by structural limitations. In this particular example, head room in the basement and the limitations of depth to that of 8 in. commercial lumber joist, dictates a uniform duct depth of 7 in. The branch duct leading to the riser of grille No. 4 would be $\frac{22}{7}$, say 3 in. in width, equivalent to 4.8 in. diameter.

Branch Duct Resistance

A considerable amount of the resistance in a system is offered by the elbows, takeoffs, transitions, and other fittings. A curve of average values of percentages of velocity head lost in elbows with various degrees of curvature is shown in Fig. 3. Much more work should be done under various conditions of velocity, shape, size, etc. to indicate whether one such curve will suffice or if a group of curves would be required before the data can be used with commercial accuracy. It is obvious

that nothing is to be gained by using elbows with a *radius ratio* greater than 2. Space limitations, manufacturing costs, use of standard fittings and many other items have a part in the actual degree of curvature adopted in each case. Where unusual circumstances do not dictate, the *radius ratios* selected for economy will not vary greatly from unity. Such an elbow would cause a drop in pressure equal to 22.0 per cent of the velocity head (Fig. 3) and with 135 F air, traveling 750 fpm, the actual drop in this elbow would be 0.031 in. w.g. $\times$ 0.22 = 0.0068 in. A stack head as ordinarily installed has a square throat, this is a *radius ratio* of 0.5, for which Fig. 3 shows 105 per cent velocity head. The resistance is equivalent to 0.031 $\times$ 1.05 = 0.0325 in. w.g.

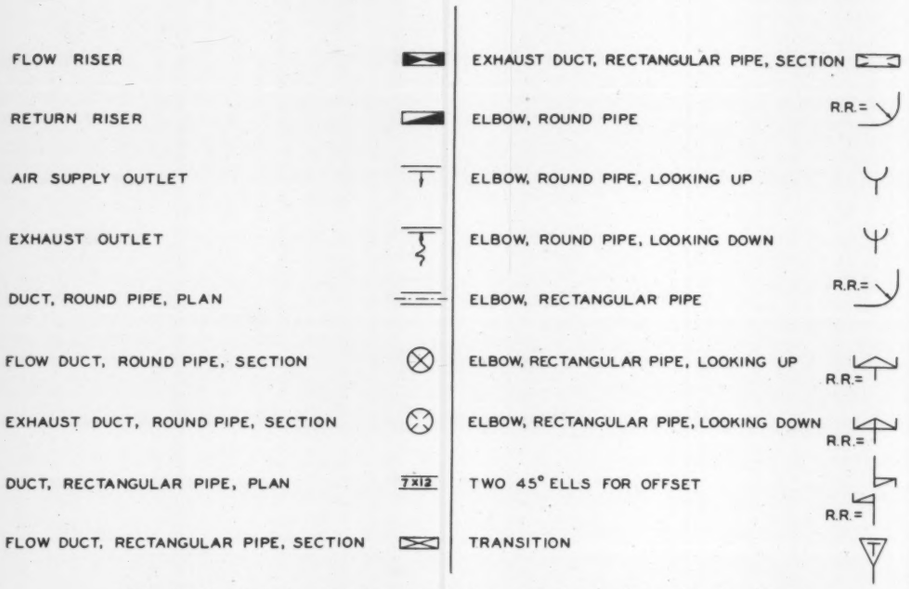

Fig. 1—Symbols for heating, ventilating and air conditioning drawings

Offsets and Transitions

It is often necessary to change the alinement of a duct to clear some portion of the structure or to reach a grille or riser. Two 45 deg ells, connected with enough pipe to provide the necessary offset, are usually employed. Such a combination of ells will not exceed in resistance that of a single 90 deg ell and can be estimated as 0.0068 in. w.g. It should be noted that all combinations of ells cannot be so easily estimated and the designer should have more complete data available.

Branch take-offs are designed in such a variety that it is impossible to attach any great weight to the values of loss in pressure due to these fittings as used in the illustrative problem. Many engineers use a combination approximating two 45 deg ells. A simple scheme illustrated in Fig. 4 is suggested. This branch take-off functions equally well for parallel and 90 deg directions and with slight modifications for other angles. In pressure drop, it is almost identical with one 90 deg ell and will be so estimated in this discussion, i. e., equal to 0.0068 in. w.g.

The loss through the transition fitting from the 3 x 7 in. branch duct, with the larger dimension vertical, to the 3 x 9 in. elbow with larger dimension horizontal, will of course depend upon the abruptness of the fitting. Very little data are available concerning the resistance of these fittings, estimated generally from 0.25 to 0.85 of the velocity head. Since in this illustrative problem the drop from 1000 to 750 fpm makes available the difference in velocity head equal to 0.025 in. w.g. which is 0.45 of the velocity head, it may be assumed that this gain will offset the loss, a fact no doubt very nearly the truth.

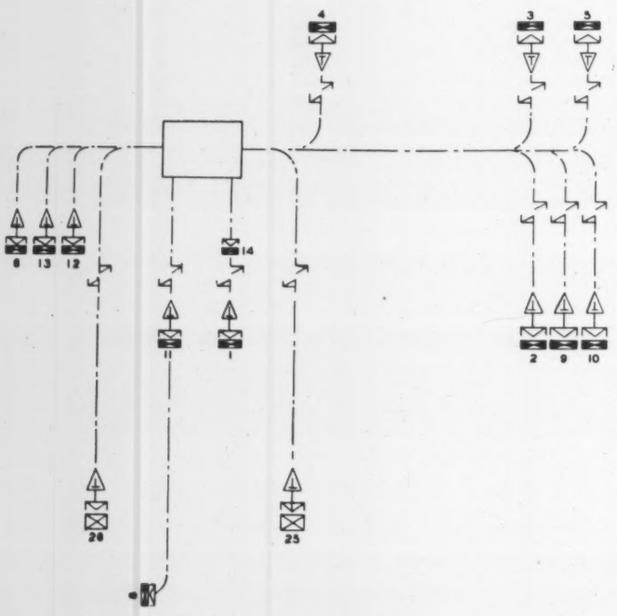

Fig. 2—Residential air flow line drawing layout

Duct Frictional Resistances

To the drop in pressure in the fittings must be added that due to friction in the straight duct. This drop may be determined algebraically by a modification of the Babcock-Unwin formula

$$p = 0.0358 \frac{flv^2r}{d_e} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots [1]$$

where

p = pressure drop, inches water gage.
f = friction factor.
l = length of duct, feet.
v = velocity, feet per second.
r = density, pounds per cubic foot.
d_e = diameter of a circular pipe or the equivalent diameter of a rectangular pipe, inches.

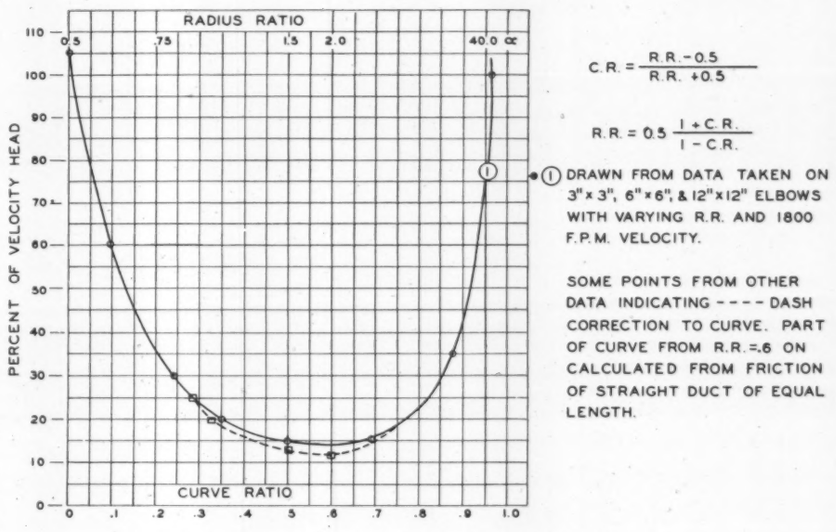
RADIUS RATIO
0.5
.75
1.5
2.0
40.0 ∞
PERCENT OF VELOCITY HEAD
CURVE RATIO
C.R. = R.R. − 0.5 / R.R. + 0.5
R.R. = 0.5 (1 + C.R.) / (1 − C.R.)
① DRAWN FROM DATA TAKEN ON 3" x 3", 6" x 6", & 12" x 12" ELBOWS WITH VARYING R.R. AND 1800 F.P.M. VELOCITY.
SOME POINTS FROM OTHER DATA INDICATING - - - - DASH CORRECTION TO CURVE. PART OF CURVE FROM R.R. = .6 ON CALCULATED FROM FRICTION OF STRAIGHT DUCT OF EQUAL LENGTH.

Fig. 3—Percentages of velocity head lost in elbows

To illustrate, check the drop in 7 feet of wall stack 3 x 9 in. leading to grille No. 4:

$l = 7$ ft.
$v = 12.5$ ft per second.
$r = 0.067$ for air at 135 F containing 45 grains of moisture per pound.
$d_e = 5.5$ in. as previously determined.
f = value determined from Fig. 5 by calculating the Reynolds Number, (R_e).
$R_e = \frac{Dv}{k}$ where k is the kinematic viscosity. From Fig. 6 the kinematic viscosity of the air in the flow risers is 20×10^{-5}.
$D = \frac{d_e}{12}$ = equivalent pipe diameter, feet.
$K = \frac{\mu}{\rho}$ = kinematic viscosity.
μ = absolute viscosity, pounds mass per foot second.
ρ = density, pounds mass per cubic foot.

$$R_e = \frac{0.46 \times 12.5}{20 \times 15^{-5}} = 28{,}750$$

The table on Fig. 5 recommends the use of curve 4 for a sheet metal duct of this size. From this curve the value of

$$f = 0.026.$$

From equation (1),

$$p = 0.0358 \frac{0.026 \times 7 \times (12.5)^2 \times 0.067}{5.5}$$
$$= 0.0123 \text{ in. w.g.}$$

The summary of the losses in this branch of duct length appears in Table 2.

To be sure that velocities and sizes will fall within reasonable limits it is desirable next to check the system which appears upon inspection to have the greatest natural resistance. The duct leading to grille No. 10 is the longest since it leads to a second floor room. It carries 100 cfm to be delivered at 500 fpm.

It is convenient to take advantage of the fact that since the resistance of both duct and fitting varies approximately with the square of the velocity the resistance of one may be expressed in terms of the other. The total resistance of the line leading to grille No. 4 in terms of an equivalent length is given in Table 3.

The duct leading to grille No. 10, estimated in the same manner, results in an equivalent length of 56.6 ft. Velocities may be roughly determined by the simple ex-

Table 2—Summary of Head Losses to Grille No. 4

Fitting	Velocity	Velocity Head	Per Cent Head Lost	Head Loss In. W. G.
Stack Head	12.5	0.031	105	0.0325
Elbow to stack	12.5	0.031	22	0.0068
Offset	16⅔	0.055	22	0.0121
Transition	16⅔	0.055	0	0.0000
Branch take-off	16⅔	0.055	22	0.0121
Riser	12.5	0.031	...	0.0123
Total				0.0758

Table 3—Total Resistance of Duct Leading to Grille No. 4

Fitting	Radius Ratio	Widths of Pipe Offering Equal Resistance	Width Ft	Equivalent Length Ft
Stack head	0.5	47.5	3/12	11.87
Elbow to stack	1.0	9.0	3/12	2.25
Offset	1.0	9.0	7/12	5.25
Branch take-off	1.0	9.0	3/12	2.25
Actual duct	.....	.....	.....	7.00
Total				28.62

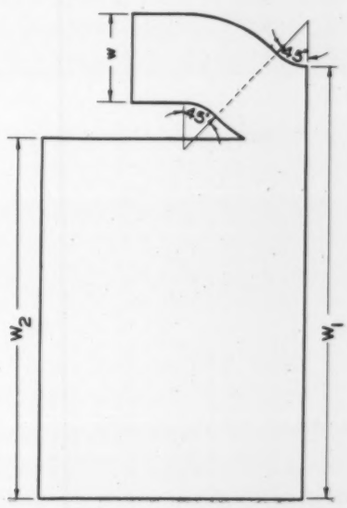

Fig. 4—Determination of branch duct sizes

W_1 = WIDTH OF DUCT BEFORE TAKEOFF
W_2 = WIDTH OF DUCT AFTER TAKEOFF
w = WIDTH OF BRANCH TAKEOFF
$W_1 = W_2 + (w - 2)$ ALL IN INCHES

pedient of equating $\left(\frac{V_2}{V_1}\right)^2 = \frac{28.6}{56.6}$, whence $V_2 = 0.7\ V_1$.

The stack velocity will be $0.7 \times 750 = 525$ fpm and in branch duct $0.7 \times 1000 = 700$ fpm. Using the nearest commercial size the riser becomes 3 x 10 in. with an actual velocity of 480 fpm and the branch duct 3 x 7 in. at 687 fpm.

A summary of the actual design head losses to grille No. 4 is given in Table 4.

Table 4—Design Summary of Head Losses to Grille No. 4

Fitting	Velocity	Velocity Head	Per Cent Head Lost	Head Loss In. W. G.
Stack head	480	0.0127	105	0.0133
Elbow to stack	480	0.0127	22	0.0028
Offset	687	0.026	22	0.0057
Branch take-off	687	0.026	22	0.0028
Riser (16.0 ft.)	480	.....	.....	0.0119
Branch duct (6.5 ft.)	687	.....	.....	0.0120
Total				0.0485

The difference between 0.0758 (Table 2) and 0.0485 (Table 4) or 0.0273 in. w.g. is for 12.5 lineal feet carrying 705 cfm. By trial and error a 7 x 12 in. duct carrying the required quantity at an actual velocity of 1210 fpm indicates a drop of 0.025 in. which balances the pressures with accuracy equivalent to that of the usual heat loss calculations.

Conclusion

It is obvious that the method employed in this discussion is a combination of the *Velocity Method* and the *Friction Pressure Loss Method* referred to on page 369 of The Guide 1937. The only velocities arbitrarily assigned are those where high values would lead to noise, or turbulence, or duct vibration. The remainder of the system is designed for equal overall friction drop without attempting to adhere to any specific pressure loss per foot of length. It is purposely left somewhat flexible in order to use, wherever possible, stock commercial sizes of duct and fittings and to permit other freedom of design. The ultimate aim is to be able to so design the system that it will reduce the amount of artificial friction, *viz.* dampers, splitters, etc. to a minimum if not entirely to zero. It is believed that the cost of power consumed by such artificial resistance will in most cases more than offset the cost of investment in more ample duct sizes. This is the *reasoning* involved in the method proposed. It is hoped that results will be commensurate with the slightly more involved plan of approach.

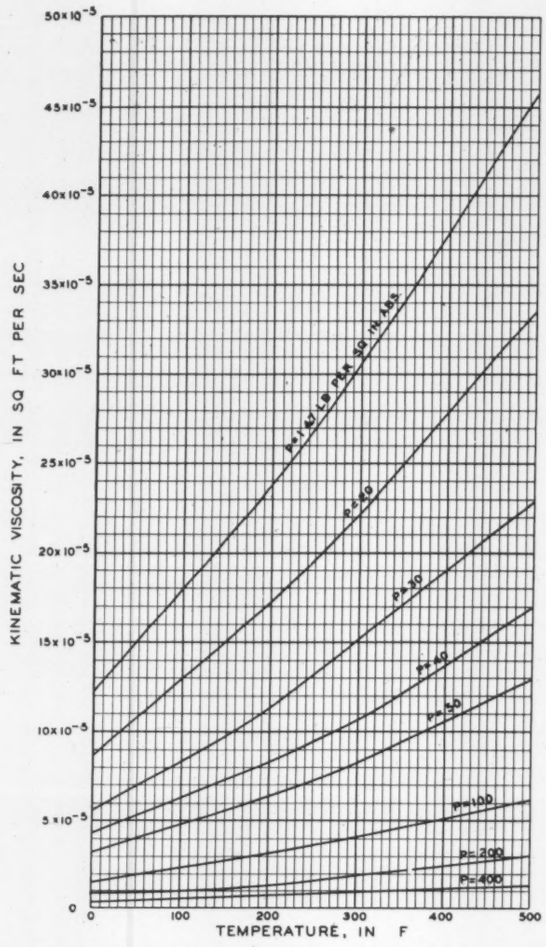

Fig. 6—Curves for determining kinematic viscosity

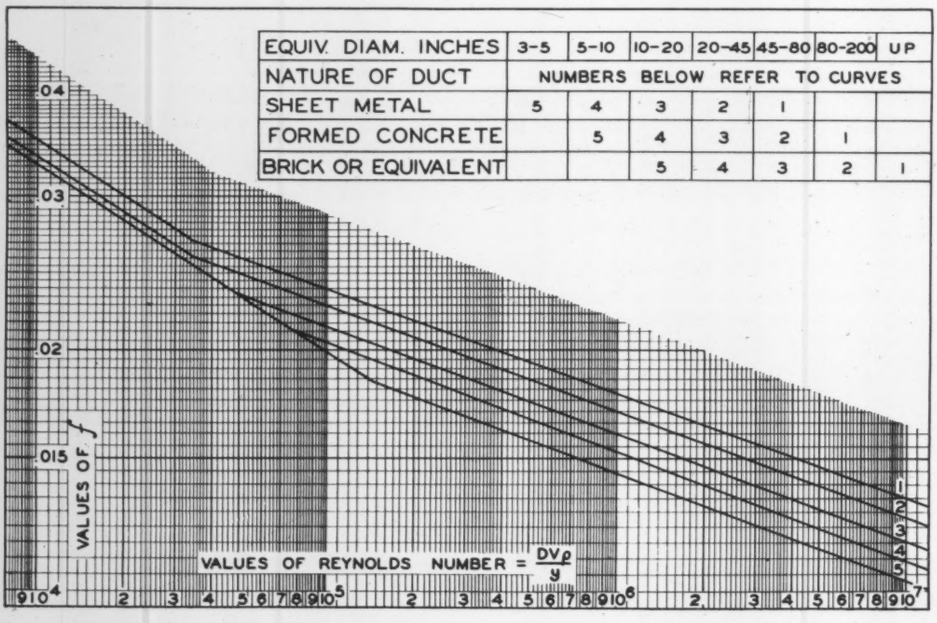
EQUIV. DIAM. INCHES 3-5 5-10 10-20 20-45 45-80 80-200 UP
NATURE OF DUCT NUMBERS BELOW REFER TO CURVES
SHEET METAL 5 4 3 2 1
FORMED CONCRETE 5 4 3 2 1
BRICK OR EQUIVALENT 5 4 3 2 1
VALUES OF f
VALUES OF REYNOLDS NUMBER = DVρ/μ

Fig. 5—Variation of friction factor with Reynolds number

Pittsburgh Experiment Station of the U. S. Bureau of Mines where the Research Laboratory of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS *is located*

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Committee on Air Conditions in Relation to Comfort: C. P. Yaglou, *Chairman;* J. J. Aeberly, R. R. Sayers, C.-E. A. Winslow.

Committee on Air Conditioning in the Treatment of Diseases: Dr. E. V. Hill, *Chairman;* N. D. Adams, J. J. Aeberly, John Howatt, A. P. Kratz, V. L. Sherman, E. L. Stammer.

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Committee on Comfort Requirements for Summer Cooling: W. L. Fleisher, *Chairman;* A. E. Beals, F. R. Bichowsky, Thomas Chester, F. E. Giesecke, Elliott Harrington, Dr. E. V. Hill, R. E. Keyes, Cyril Tasker, C. P. Yaglou.

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Committee on Corrosion in Heating Systems: J. H. Walker, *Chairman;* E. L. Chappell, W. H. Driscoll, C. A. Dunham, L. B. Miller, R. R. Seeber, C. M. Sterne.

Committee on Direct and Indirect Radiation with Gravity Air Circulation: M. K. Fahnestock, *Chairman;* H. F. Hutzel, J. P. Magos, J. W. McElgin, J. F. McIntire, D. W. Nelson, R. N. Trane, T. A. Novotney.

Committee on Effect of Entering Temperature and Velocity on Temperature and Distribution of Air Within an Enclosure: Ernest Szekely, *Chairman;* S. H. Downs, M. K. Fahnestock, D. W. Nelson, C. H. Randolph, J. E. Schoen, G. L. Tuve, J. H. Van Alsburg.

Committee on Frictional Resistance to Flow of Air in Small Ducts and Fittings: J. H. Van Alsburg, *Chairman;* C. A. Booth, S. H. Downs, R. D. Madison, L. B. Miller, L. E. Smith, C. M. Humphreys.

Committee on Heating and Cooling Requirements of Buildings: O. W. Armspach, *Chairman;* P. D. Close, W. H. Driscoll, H. M. Hart, P. E. Holcombe, V. W. Hunter, H. H. Mather, E. C. Rack, F. B. Rowley, R. J. J. Tennant, J. H. Walker.

Committee on Heat Transfer of Finned Tubes with Forced Air Circulation: F. B. Rowley, *Chairman;* H. F. Hutzel, C. E. Lewis, E. J. Lindseth, R. H. Norris, W. E. Stark, G. L. Tuve.

Committee on Intermittent Heating of Churches, Auditoriums and Similar Buildings: E. K. Campbell, *Chairman;* W. L. Cassell, Prof. E. F. Dawson, N. W. Downs, J. M. Robertson, J. H. Kitchen, Prof. A. H. Sluss.

Committee on Insulation: L. A. Harding, *Chairman;* E. A. Allcut, J. D. Edwards, E. C. Lloyd, R. T. Miller, E. R. Queer, T. S. Rogers, F. B. Rowley, W. S. Steele, Cyril Tasker, B. Townshend, G. B. Wilkes.

Committee on Psychrometry: F. R. Bichowsky, *Chairman;* C. A. Bulkeley, J. A. Goff, Dr. E. V. Hill, F. G. Keyes, A. P. Kratz, W. M. Sawdon.

Committee on Railroad Air Conditioning: A. I. Brown, *Chairman;* F. E. Giesecke, C. S. Leopold, S. R. Lewis, L. W. Wallace.

Committee on Refrigeration in Relation to Air Treatment: M. K. Fahnestock, *Chairman;* E. A. Brandt, John Everetts, Jr., Elliott Harrington, E. D. Milener, K. W. Miller, E. B. Newill, F. G. Sedgwick, J. H. Walker.

Committee on Sound in Relation to Heating and Ventilation: J. S. Parkinson, *Chairman;* C. M. Ashley, C. A. Booth, V. O. Knudsen, R. F. Norris, C. H. Randolph, J. P. Reis, F. R. Watson.

Committee on Treatment of Air with Electricity: Prof. C.-E. A. Winslow, *Chairman,* Prof. Vannevar Bush, W. H. Carrier, L. W. Chubb, Major W. D. Fleming, R. F. James, L. R. Koller, Dr. C. A. Mills, Prof. E. B. Phelps, Prof. C. R. Wait, Prof. W. T. Wells.

Report of Committee on Research for 1936

A Review and Forecast

By W. A. Danielson* and F. C. Houghten**

A Review of 1936

THE Committee on Research of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS held four meetings during 1936. The retiring committee for 1935 met in Chicago during the 42nd Annual Meeting of the Society and approved a budget prepared by the Finance Committee to be submitted for final approval by the 1936 Committee, and transacted other business pertaining to the previous year's activity.

An organization meeting of the 1936 Committee followed, at which time the new Chairman for 1936 was elected, the budget proposed by the retiring committee was adopted, and a research and finance program for the year was discussed. The committee also considered a number of matters of interest to the Laboratory, including the appointment of several Technical Advisory Committees. Two meetings of the Committee were held during the Semi-annual Meeting of the Society at Buck Hill Falls, Pa., when a number of matters pertaining to a reorganization of the Technical Advisory Committees and methods of financing the work of the Committee received extended discussion. The closing meeting of the 1936 Committee will be held in St. Louis during the 1937 Annual Meeting of the Society.

Financial Position Improved

For the third successive year following the depths of the depression, the Committee worked under a slightly enlarged budget and closed the year in an improved financial condition. Besides carrying on a number of studies at Pittsburgh, work was continued in eight universities. The better financial outlook of the Committee during the latter part of the year, and the receipt of a $4,000 appropriation from the Council of the Society made possible an expansion in the Laboratory budget and a renewal of the Committee's successful practice of helping to finance cooperative research in a number of Universities, after a lapse of several years in such aid during the depression. This renewed financial relationship with the cooperative institutions has encouraged an expansion in research activity which should greatly increase the results obtained during the coming year.

By far, the most important development of the work of the Committee during the year was the re-organization of the Technical Advisory Committees in accordance with a comprehensive organization plan shown in Fig. 1. According to this plan, the interests of the Committee on Research have been divided into two major and several minor divisions. The first major division includes all studies and developments dealing with air conditioning in their relation to the comfort and health of man, air conditioning applications dealing with animals and plant life, and the conditioning treatment of by-products from the same.

W. A. Danielson
Chairman, Committee on Research

Organic Division

This major branch, known as the Organic Division, as contrasted with a similar "inorganic" division, was organized under W. L. Fleisher, acting as assistant chairman of the Committee on Research. Under the sub-division of "Humans" are included any studies made by the Research Laboratory dealing with the desirable atmospheric conditions for human comfort and well-being, both in the summer and winter, the effects of drafts on comfort, the relation between odors and the volume of ventilation in occupied spaces, and the treatment of various diseases either for curative effect or for optimum comfort condition of the patient receiving other treatment.

Inorganic Division

The Inorganic Division was organized into two major subdivisions covering "fundamentals" and "performance," headed respectively by Thomas Urdahl and E. W. Goodwin, acting as assistant chairmen of the Committee on Research. The Fundamentals Sub-division gives consideration to any fundamental knowledge pertaining to materials used in building construc-

*Chairman.
**Director of the Research Laboratory.
Presented at the 43rd Annual Meeting of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, St. Louis Mo., January, 1937.

tion or the manufacture of equipment. Such fundamental physical phenomena as heat, its transfer, and the physical and chemical qualities of the air are included in this sub-division of research activity. The Performance Sub-division deals with the performance or service of systems of heating, ventilating and air conditioning, and other equipment used in such systems, together with such practices as the generation of heat from fuels and methods of obtaining mechanical cooling.

For want of other location, two other activities of the Committee have been considered in parallel with the Organic and Inorganic Divisions, namely, the subjects of "climate in relation to the health and well-being of man," and "psychrometry."

Technical Advisory Committees

Under these major and minor divisions of the interests of the Committee on Research have been developed twenty-one Technical Advisory Committees, while several others have been proposed. With this comprehensive sub-division of the interests of the Committee, it is hoped that when any new question needing laboratory, library or committee investigation is proposed it may be immediately allocated to a Technical Advisory Committee already organized, thus avoiding delays in organizing such work, as well as the overlapping of responsibilities of Technical Advisory Committees appointed in haste when the need for the same arises.

A great deal of time and energy were required during the year in developing this re-organization and the appointment of the Technical Advisory committees. This naturally resulted in a delay in the organization of the committees themselves and of their several programs of operation, and hence, the reported activities of the committee in the appendix to this report will in some cases indicate little activity beyond organization. This has not, however, resulted in any delay in any of the projects assigned to the Research Laboratory or cooperating institutions by the Committee on Research, which have been carried on as energetically as finances and personnel have permitted. It is hoped that with the re-appointment of these same committees during the coming year their work will go forward without interruption and with improved performance.

Study of Finance Methods

The method of helping to finance the research work of the Committee by voluntary subscriptions from industry was given a great deal of consideration, and a number of possible methods of organizing such efforts for the year were considered. With the improved economic condition of industry it has been thought that while the time for such a campaign has not yet been reached, the ground work should be laid for carrying on such a campaign in the very near future. With this in view, considerable effort has been made in the organization of the work of the Finance Committee, with a view

C. E. Lewis
Vice-Chairman
Committee on Research

F. C. Houghten
Director, A.S.H.V.E.
Research Laboratory

of placing before prospective contributors a comprehensive program of work to be carried on and facts concerning the value of the work of the Committee on Research to this branch of the engineering profession and industry.

While the time was not considered ripe to push this effort to an ultimate conclusion during the year, a number of worthwhile results have accrued, including the receipt of $1,425 in earmarked contributions and $100 in non-earmarked contributions. It is believed, however, that these contributions should not be considered as a measure of the fruitfulness of the work carried on during the year, but that more comprehensive contributions should result during the early part of 1937 from the effort already expended.

Educational Publicity

Paralleling the development of the work of the Finance Committee, a Publicity Committee has been organized in order to properly place the importance and value of the Committee's work before the industry and financial institutions profiting by the growth in air conditioning. In this connection, the services of Brewster S. Beach, as publicity counsel, have been engaged, who has already carried on a number of activities which it is believed are approaching fruitfulness. While the results of these activities are not demonstrated in the financial returns to date, it is believed that the ground work has been laid, as a result of which further developments will take place during 1937.

Altogether, the work of the 1936 Committee may be considered as a transition in the life of the Research Laboratory, during which reorganization activities have been carried on aiming to return the Laboratory from a "depression" to a normal economic basis, and it is hoped that the success reflected in the results to be obtained during the next few months will amply demonstrate the wisdom of these efforts.

VITAL PROBLEMS IN RESEARCH FOR THE COMING YEAR—A FORECAST

Many vital problems face the Committee on Research for the coming year. Chief of these are the extension of knowledge as to how air conditioning can be utilized more effectively in the treatment of disease, the broadening of investigations and the development of new facilities and methods for testing insulation and further work in determining standards for summer comfort cooling embracing the whole subject of the physiological aspects of air conditioning, heating and ventilating.

Emphasis on Insulation

Considerable emphasis it is expected will be placed on the problems on insulation as it is felt these are fundamental to all branches of the industry. Among the sub-divisions of this work may be mentioned studies of heat losses and gains through glass, correct practice for the use of glass brick in buildings, commercial development of water covering for roofs as insula-

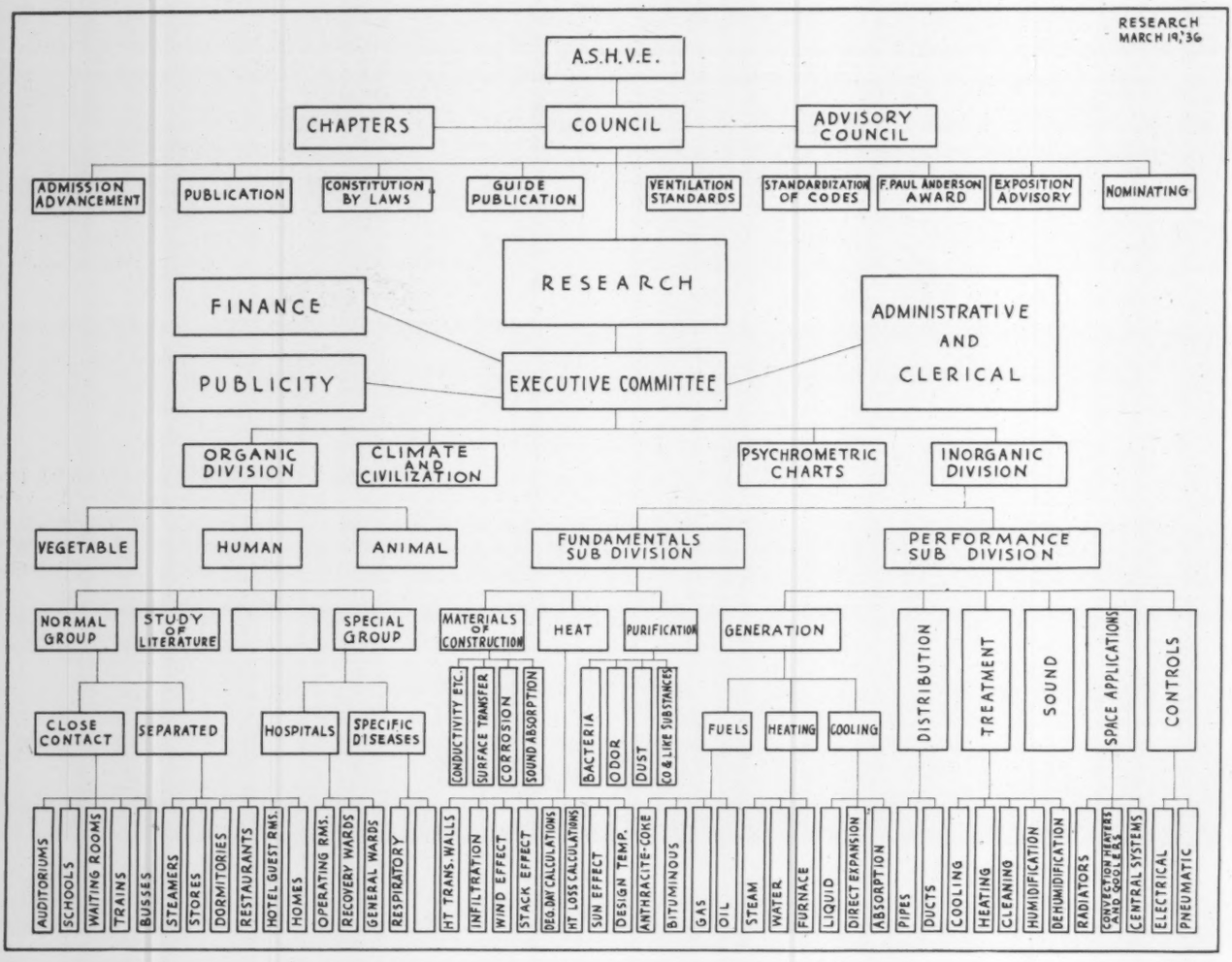


Fig. 1—Functional Organization Chart

tion and to lengthen roofing material life, best ways of insulating glass in buildings to prevent infiltration of cold in heated buildings and further studies of glass as a "heat trap."

Special attention needs to be given to methods of installing insulation in buildings, particularly homes, to avoid settling, provide tight fitting and in other ways to eliminate or minimize the deleterious effect of humidified air from within the building itself on the insulation materials themselves.

These studies must encompass investigation of double glass windows and other insulation methods including reflective materials, board insulation and fill-type insulation. More advanced methods for testing all insulation materials as well as testing standards will be required in the immediate future. The importance of this work is especially apparent with the rapid growth in new building construction already approaching boom proportions. Serious monetary losses and damage to builders' and engineers' reputations may be the result of failure to improve scientific knowledge of the subject of insulation materials including methods for their correct application.

Thirty Problems Listed

The Committee on Research has listed some 30 subjects that are desirable for study in all fields of heating, ventilating and air conditioning. Among those not already mentioned is the study of what constitutes a draft, recognizing that this subject is one which causes complaints from the public in ventilating and air conditioning systems. The physiological effect of the so-called draft and its relation to a feeling of comfort or discomfort will be investigated. This subject on the other hand, is also bound up in the broad problem of air distribution. The Committee expects to study further the proper method and place of introduction of air for room cooling and the safe limits of difference in temperature between the room and incoming air. Also the practical limitations of air velocity and difference in temperature between room temperature and air delivery temperature in the use of unit ventilators for heating and ventilating school rooms.

Related to these problems also is the question of noise generated in air distributing systems and the whole broad subject of noise in relation to heating and ventilating both in ducts and through air discharge outlets. Steam and hot water heating systems should come in for a special share of attention. Included in this work is research on the calculated drop in temperature through a radiator in forced circulation hot water heating, determination of the simplest and lowest-cost low pressure steam and hot water heating systems for small homes, and use of small pipes in forced hot water circulation systems.

The increasing complexity of air conditioning and the arts allied to it, demand a type of fundamental research that will help to stabilize the engineering and scientific side of these industries in the face of growing public demand for air conditioning applications of many new kinds. Research must keep pace with the rapid increase in the tempo of modern selling methods in order that heating, ventilating and air conditioning

Papers Resulting From Research During 1936

Twelve technical papers, resulting from research carried on in Pittsburgh or in the cooperating institutions under the several Technical Advisory Committees were prepared for presentation at meetings of the Society and published in the A.S.H.V.E. JOURNAL. They are listed below and will be referred to by number in the discussion of research projects carried on by Technical Advisory Committees in the latter part of this report.

1. Thermal Properties of Concrete Construction, by F. B. Rowley, A. B. Algren and Clifford Carlson. Presented at the Annual Meeting, January, 1936.
2. Comfort Standards for Summer Air Conditioning, by F. C. Houghten and Carl Gutberlet. Presented at the Annual Meeting, January, 1936.
3. Performance of Fin Tube Units for Air Heating, Cooling and Dehumidifying, by G. L. Tuve. Presented at the Annual Meeting, January, 1936.
4. Ventilation Requirements, by C. P. Yaglou, E. C. Riley and D. L. Coggins, January, 1936, Journal.
5. Corrosion Studies in Steam Heating Systems, by R. R. Seeber, F. A. Rohrman and G. E. Smedberg; February, 1936, Journal.
6. Study of Summer Cooling in the Research Residence Using Water from the City Water Mains, by A. P. Kratz, M. K. Fahnestock, S. Konzo and E. L. Broderick; May, 1936, Journal.
7. A Field Study of the Heat Requirements of a College Building, by F. E. Giesecke and W. H. Badgett; June, 1936, Journal.
8. Heating Requirements of an Office Building as Affected by Weather Conditions, by F. C. Houghten and Carl Gutberlet; July, 1936, Journal.
9. Condensate and Air Removal Rates in a Vacuum Heating System, by D. W. Nelson; October, 1936, Journal.
10. Thermal Properties of Concrete Construction, by F. B. Rowley, A. B. Algren and Robert Lander; November, 1936, Journal.
11. Cooling Requirements for Summer Comfort Air Conditioning, by F. C. Houghten, F. E. Giesecke, Cyril Tasker and Carl Gutberlet; December, 1936, Journal.
12. Fever Therapy Induced by Air Conditioning, by F. C. Houghten, M. D. Ferderber and Carl Gutberlet. To be presented at the Annual Meeting, January, 1937.

may march forward in orderly fashion with a secure foundation of basic research facts behind them.

Research Activities Considered by Technical Advisory Committees, and Work Carried on Under Such Committees During 1936

During the year 21 Technical Advisory Committees were appointed to consider as many different sub-divisions of technical knowledge on which this branch of engineering profession is based. As stated above, a number of these committees have been appointed only long enough to perfect an organization, and little in the nature of technical results are available from their efforts. However, in a few cases work has been continued under committees appointed in former years and under which definite research has been carried on. The personnel of each of the Technical Advisory Committees working under the Committee on Research, and a discussion of the work considered, organized, or carried on, during the year, are given.

Technical Advisory Committee IF-1

SOUND IN RELATION TO HEATING AND VENTILATION

J. S. Parkinson, *Chairman*

C. M. Ashley
C. A. Booth
V. O. Knudsen
R. F. Norris
C. H. Randolph
J. P. Reis
F. R. Watson

This committee has done very little work during the course of this past year. It feels that its principal function was fulfilled in collecting available information for the use of the Society and recommending the necessary research to complete the desired data. There is very little research activity along these lines, and the principal efforts of the committee have been directed toward interesting different organizations in such research.

The committee has prepared a table of noise levels which are considered typical for various room locations, with the range of variation which is likely to be encountered. On the basis of these tabulated levels, the committee has recommended certain maximum permissible figures for the noise of equipment in such spaces. The committee has cooperated with Mr. Hotchkiss and the GUIDE Publication Committee in revising the Chapter on "Sound" for the 1937 GUIDE. It has likewise developed a research program aimed to make possible the rating of the noise generated by ventilating and conditioning apparatus.

The general situation is very much the same as it was when the committee met in July at Buck Hill Falls. We are in a position to say what noise levels are permissible and are beginning to have data available as to the reductions encountered through the ventilating system with and without absorbent linings. Lacking data as to the original noise created by the equipment, it is at present impossible to specify the levels in the finished installation with any degree of accuracy. This is a problem which clearly calls for collective action on the part of the manufacturers and the Society.

Technical Advisory Committee IF-2

CORROSION IN HEATING SYSTEMS

J. H. Walker, *Chairman*

E. L. Chappell
W. H. Driscoll
C. A. Dunham
L. B. Miller
R. R. Seeber
C. M. Sterne

Institutions Cooperating with the Committtee on Research

Agri. & Mech. College of Texas

(1) Comfort Requirements in Summer Cooling.
(2) Dissipation of heat from pipes buried in ground with reference to cooling of buildings.
(3) Efficiency of water jet pumps as used in central forced circulation water heating systems.

Case School of Applied Science

Heat transfer of finned tubes with forced air circulation, including dehumidification data.

Harvard School of Public Health

Minimum outdoor air requirements for ventilation, particularly with relation to odors.

University of Illinois

(1) Direct and Indirect Radiation with Gravity Air Circulation.
(2) Cooling of buildings in Summer.
(3) Air Conditioning in the Treatment of Diseases.

Marquette University

Methods of air supply and distribution in air conditioning.

Michigan College of Mining & Technology

Corrosion in steam heating returns under controlled laboratory conditions, with relation to composition of the water, vapor and gas handled.

University of Minnesota

(1) Heat Transmission through Building Materials.
(2) Method of testing dust filters.

Ontario Research Foundation

Summer cooling comfort requirements.

Princeton University

Measurement of Air Flow through Exhaust Grilles.

University of Wisconsin

(1) Air and Condensate Removal in steam heating returns.
(2) Methods of air supply and distribution in air conditioning.

The principal function of this committee has been to cooperate with the Michigan College of Mining and Technology in the study of corrosion of ferrous metals in heating systems. The project has been under way since June, 1933, and papers in the nature of progress reports were presented by Professor R. R. Seeber, who is in charge of the project, at the 1934 Meeting and at the 1936 Summer Meeting[1] of the Society.

The general purpose of the study is to determine the effect on corrosion of various amounts of carbon dioxide and oxygen in the steam supply. Due to the complex and difficult nature of the observations, it is expected that at least another year will elapse before the final results can be presented.

Up to midsummer of 1936, the work was entirely financed by the College. Recently a fund of nine hundred dollars for its partial support during 1936-37 was subscribed by several public utility companies engaged in district heating, but the major portion of the financial support is still being contributed by the College.

Technical Advisory Committee OH-3

AIR CONDITIONING IN THE TREATMENT OF DISEASE

Dr. E. V. Hill, *Chairman*

N. D. Adams
J. J. Aeberly
John Howatt
A. P. Kratz
V. L. Sherman
E. L. Stammer

The report of this committee at the present time can be only one of progress, although it is possible that there will be some research data of interest by the time of the Annual Meeting in January.

Considerable unavoidable delay was experienced in getting the program at the Research and Educational Hospital of the Medical College of the University of Illinois under way. It was first necessary to build an experimental air conditioning system to be used in connection with an experimental hospital room. This was accomplished through the generous support of manufacturers in supplying the equipment and in many cases aiding in installing and putting the same into operation. Otherwise, the installation and remodeling was carried on wholly by the hospital staff. In spite of these difficulties, the installation was finally completed and the apparatus finally put into operation on the first of November. It has since been operating continuously and in a very satisfactory manner.

The set-up at the Research Hospital consists of an equipment room and a small two-bed ward. The two rooms are adjacent. The equipment room contains supply and exhaust fans, duct work for recirculating any or all of the air or taking any part required from out-of-doors, special filters for air cleaning, a 3-ton compressor with shell and tube cooler, circulating pump, and fin type coils in the air passage to the supply fan, a silica gel dehumidifier for reducing the moisture content of the air, a steam jet humidifier for increasing the humidity, all under automatic control.

The ward is approximately 12 by 14 ft in area with no outside windows; it is insulated with three inches of cork; the temperature range that can be maintained is from 50 to 100 F dry-bulb, 20 to 90 per cent relative humidity. The staff conducting the research work consists of Dr. R. W. Keeton, head of the Department of Medicine at the Research and Educational Hospital, Dr. F. K. Hicks, and Mr. N. Glickman, with some assistance from the chairman of the committee.

The preliminary program undertaken is the exploration of the physiological reactions of normal and abnormal cases under various psychrometric conditions. At the present time this program includes: (1) the determination of cardiac output, i.e., the number of liters of blood per minute that leaves the heart, which is accomplished by the injection of a harmless dye into the venus blood stream and timing its circuit and appearance in the arterial flow; (2) skin temperature observations are made at each test, at five points on the body, namely, the forehead, both forearms, and both thighs; (3) the metabolic rate is also determined, both the oxygen consumption and the CO_2 output being measured. The program will be limited to these observations for the present. Later it will be amplified.

In making the tests referred to, the research staff is following a very definite psychrometric procedure, starting at a given wet-bulb temperature as near the saturation curve as possible; then, the tests are continued with increasing temperature and lowered humidities, staying always on the wet-bulb curve selected. When the physiological responses on this curve are completed, another will be selected, possibly three in all; then, the same procedure will be followed in exploring dew-point lines on the chart, also relative humidity lines, and finally, the dry-bulb lines. In this way it is hoped to find the physiological effect of different air conditions, and it should be possible by following this procedure to properly evaluate such efforts, whether they are due to dry-bulb temperature, to relative humidity, or to any other psychrometric function.

Technical Advisory Committee IP-4

ATMOSPHERIC DUST AND AIR CLEANING DEVICES

H. C. Murphy, *Chairman*

M. I. Dorfan
S. R. Lewis
G. W. Penney
D. C. Simpson
W. O. Vedder

The work of this committee, formerly covering all phases of the dust and air pollution problem, was divided during 1936, this committee continuing to interest itself in air cleaning devices as applied to ventilation and air conditioning problems, while the Technical Advisory Committee on Atmospheric Impurities and Resulting Safety and Health Requirements is now working on other phases of the subject.

This committee has continued its work on the formation of a code for the selection and rating of air cleaning and dust eliminating devices intended to supply satisfactory air for dust hazardous occupations. This is intended to supplement the Code for Air Cleaning Devices Used in General Ventilation Work, which the Society has already adopted as a standard.

The committee worked with the United States Bureau of Standards in the development of new test procedures and had hoped that these developments would be sufficiently advanced to warrant a paper at the January meeting. It now seems advisable, however, to postpone this paper to a later date. The committee has endeavored to keep in touch with new developments in this field and has attended wherever possible meetings of scientific and engineering associations where these matters have been under discussion.

It is still felt that the committee's suggestion of a clearing house for information of this kind is worth considering. There are innumerable investigations and reports of great importance to our profession which become available every day but nowhere is this information tabulated and correlated so that it will have maximum value for our members and the public in general.

The investigations of Mr. O. C. Durham of Chicago as to distribution of pollen in the air has enabled engineers to provide pollen-free spaces and considerable relief of seasonal hay-fever, bronchial asthma and similar allergic disorders. The aerial survey of air-borne organisms conducted by the Lindberghs in 1933 for the U. S. Department of Agriculture has brought new conceptions as to the transmission of plant diseases. The recent report of the University of California on the "Distribution of Disease by Trans-Pacific Airplanes"; the recently published investigation of the Harvard Observatory covering particle sizes of dust in the outer atmosphere, and many other worth while

investigations appear daily, without any attempt to correlate them.

The committee feels that an extension of the work done in the "Correlation of Thermal Research" could be attempted at the Research Laboratory in Pittsburgh without undue cost and with real benefit to the Society and the public in general.

Technical Advisory Committee OH-5

AIR CONDITIONS AND THEIR RELATION TO LIVING COMFORT

C. P. Yaglou, *Chairman*
J. J. Aeberly — R. R. Sayers
C. E. A. Winslow

The cooperative study between the Society and the Harvard School of Public Health on minimum outdoor air requirements for ventilation was completed this Autumn. A progress report on this work was presented at the last annual meeting in Chicago, and the final report will be available in the near future.

Provisional values given in the preliminary report were reinforced with additional observations during the year. Among the new points studied are the influence of winter humidification and spray washing on odor removal, rate of disappearance of various odors in unventilated rooms, and the effects of temperature, humidity, seasonal changes, etc., on the intensity of body odor. The conventional spray humidifier, using clean water at the rate of 15 gpm per 1000 cfm of air circulated, was found to be fairly efficient in odor removal, allowing a great reduction in the outdoor air supply, with a corresponding increase in the recirculation rate up to 85 per cent under the experimental conditions.

Owing to pressing work in other directions, the committee feels that the determination of ventilation requirements for smoking rooms and methods of removing tobacco smoke odors had better be deferred for some future time or set aside for solution by manufacturers of air conditioning equipment.

A concerted effort should be directed toward the solution of the problem of summer cooling for comfort, and of the factors contributing to the causation of drafts. Much valuable work on these two problems is now being done by the Society's Research Laboratory and other interested institutions. The program should, however, be modified or expanded to deal with physiological rather than physical aspects, i.e., the ability of individuals to meet sudden changes in the physical components of the air without disturbance in the physiological balance. By far the greatest effort should be directed to studying the nature of physiologic response to sudden and frequent changes in temperature and humidity, when the body is warm and perspiring, and the air conditions most conducive to comfort with the least adaptive response.

In this connection, the Chairman of the Committee is strongly in favor of a thorough study of adsorption dehumidification methods and of the possibility of securing comfort in hot weather largely by reduction of humidity with but a few degrees drop in temperature. Considerable evidence was obtained during the past five years to justify a thorough study along such lines.

The Committee wishes to call attention to two important publications during the year, that of T. Bedford on "The Warmth Factor in Comfort at Work," and those of Winslow and his associates at the John B. Pierce Laboratory of Hygiene. Both of these studies deal essentially with the assessment of thermal factors influencing human comfort.

Technical Advisory Committee IP-6

FRICTIONAL RESISTANCE TO FLOW OF AIR IN SMALL DUCTS AND FITTINGS

J. H. Van Alsburg, *Chairman*

C. A. Booth	L. B. Miller
S. H. Downs	L. E. Smith
R. D. Madison	C. M. Humphreys

This committee was organized during 1935 to make a thorough study of the available data on frictional resistance in all types of ducts and fittings, particularly of small sizes. This might be considered a check on the friction chart now appearing in the A.S.H.V.E. GUIDE. The committee met during each convention following its appointment and outlined a program including plans for a laboratory set-up which has since been built up and used at the Research Laboratory in Pittsburgh.

The first series of tests consisted of determining the resistance in an 8-inch round pipe. This set-up consisted of 10-ft sections giving a total length of 64 ft of straight duct, followed by an elbow, a section of straight duct, another elbow, and another section of straight duct equipped with a throttling cone. This duct system was attached to a 12-inch section, which was attached to the blower. The 12-inch section was equipped with a suitable orifice plate and pitot tube installation for making volume flow readings, and the necessary air straightening devices. After the first tests were reported, giving results differing from other organizations, the data were checked to the Reynolds number and all bibliography was checked to determine the reason for the variation between the new data and that published in the friction chart. The values of the factors obtained from the Laboratory's test data are lower than any other data found on galvanized pipe of the same diameter. This difference may be due in part to the use of smoother duct by the Laboratory, but probably to a greater extent to large factors of safety used in the friction chart.

The committee has developed plans for continuing the work at the Research Laboratory. These plans include studying square and rectangular ducts of equivalent capacity to the 8-inch round duct, with various elbows and other fittings. A similar study will then be made on at least one larger size of duct with different dimensions.

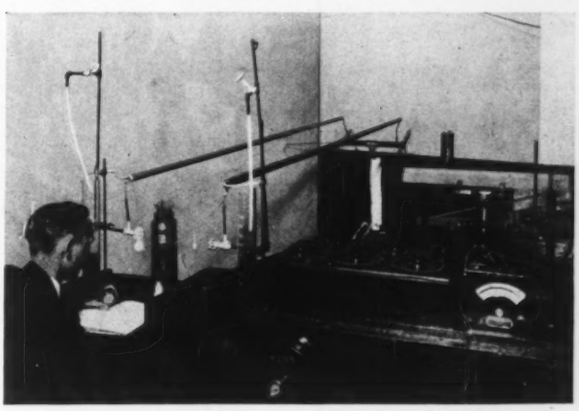
Technical Advisory Committee IP-7

REFRIGERATION IN RELATION TO AIR TREATMENT

M. K. Fahnestock, *Chairman*

E. A. Brandt	K. W. Miller
John Everetts, Jr.	E. B. Newill
E. D. Harrington	F. G. Sedgwick
E. D. Milener	J. H. Walker

The studies in summer cooling carried on at the Research Residence by the University of Illinois in cooperation with the Research Laboratory and the National Warm Air Heating and Air Conditioning Association were continued through the summer of 1936 for the purpose of completing the test program approved and started in 1935. This program was to determine the operating characteristics of the resident cooling plant when using water at three different temperatures; namely, 58, 52,



Set-up for determining heat emission from bare and insulated copper and iron pipe placed in a horizontal position, at the A.S.H.V.E. Research Laboratory, Pittsburgh

and 45 F, in extended surface cooling coils. The summer of 1935 was relatively cool, and only the series of tests using water from the city supply mains at a temperature of 58 F was completed during that summer. A complete report[6] of that work was made before a joint meeting of the Society and the National Warm Air Heating and Air Conditioning Association, held during their annual meetings in Chicago in January.

The unusually warm summer of 1936 permitted the completion of the two remaining series of tests, using water with temperatures of 52 and 45 F. The arrangement of the test plant, with the exception of the refrigerating equipment for supplying chilled water, was the same as during 1935. The condensing unit and water cooler for supplying chilled water were located outside of the residence in order to prevent the introduction of heat from mechanical equipment which was not used during 1935, when the cooling water was taken directly from the city mains. Over the entire period of time requiring cooling the air circulating fan operated continuously and outdoor air equivalent to one air change per hour was brought into the house for ventilating purposes. The indoor temperature control was effected through a dry-bulb thermostat set at 80 F, which served to start and stop the circulation of chilled water through the cooling coil by the operation of a water circulator. The temperature of the chilled water entering the cooling coil was regulated by a thermostatically operated water mixing valve. The same amount of cooling coil surface, eight rows deep in the direction of air flow, was used during all tests in 1935 and 1936.

The committee has the following program under consideration for possible future study:

1. A study of evaporative cooling of residences, involving a test program in the Research Residence.
2. A study of the use of a forced-draft cooling tower, including the design of same, for the purpose of reducing the quantity of cooling water required with mechanical refrigeration. This might also include a study of the use of evaporative condensers.
3. Consideration for a survey of existing data and information available on residence cooling installations in an attempt to determine why there is such a large variation in the recommended and actual capacities of refrigeration equipment for moderate size houses.
4. A continuation of one season of mechanical cooling, if and when the Research Residence is insulated.

Technical Advisory Committee IF-8

HEATING AND COOLING REQUIREMENTS OF BUILDINGS

O. W. Armspach, *Chairman*

P. D. Close	H. H. Mather
W. H. Driscoll	E. C. Rack
H. M. Hart	F. B. Rowley
P. E. Holcombe	R. J. J. Tennant
V. H. Hunter	J. H. Walker

This committee has been most active over a period of years in making a comprehensive study of the heating requirements of buildings. In this connection a large number of studies were initiated and carried on at the Research Laboratory and at several cooperating universities. During the past year the estimation of cooling requirements of buildings has been added to the responsibilities of the committee.

There has been little change in the active program of the committee during the current year, but a number of the activities outlined for a long time program have been continued. Additional data collected in the Grant Building were analyzed by the Research Laboratory and a paper[8] was presented to the Semi-Annual Meeting of the Society. Additional data remain to be analyzed in connection with this study which will result in another report at some future date.

A study of the heating requirements of Sibley Dome, one of the Cornell University buildings, has been continued. Data in connection with this study were collected at an earlier date by Mr. Ward, Superintendent of Buildings and Grounds at Cornell University, and the results are now being analyzed by a subcommittee with a view of presenting a paper to the Society.

A study was made of the heat requirements of one of the buildings at the Agricultural and Mechanical College of Texas by Professor Giesecke. This work extended over the past heating season and resulted in a paper[7] presented at the Semi-Annual meeting of the Society. Professor Giesecke is continuing this study.

The study of heat transfer through various types of concrete construction was continued at the University of Minnesota by Professor Rowley in cooperation with the Society and the *Portland Cement Association.* A paper[10] resulting from this study was presented at the last Annual Meeting of the Society, and a second paper[10] will be presented at the coming Annual Meeting.

A study of condensation and air return rates in the heating of a large school building was continued at the University of Wisconsin in cooperation with the Laboratory, resulting in a paper which was presented at the Semi-Annual Meeting of the Society.

The study of the use of the "degree-day" method of estimating fuel consumption was continued by a sub-committee. A report on this phase of the work is expected at an early date.

The various activities of the committee will be continued through 1937. In addition to these continued activities, a further study of heat transfer through roofs and walls of buildings as affected by heat capacity and solar radiation under practical conditions has been approved by the Committee on Research, and it is hoped that finances will allow an active investigation of the subject during the coming summer months.

Technical Advisory Committee IP-9

DIRECT AND INDIRECT RADIATION WITH GRAVITY AIR CIRCULATION

M. K. Fahnestock, *Chairman*

H. F. Hutzel	D. W. Nelson
J. P. Magos	R. N. Trane
J. W. McElgin	T. A. Novotney
J. F. McIntire	

Although the work of the committee has been considerably curtailed during the past year, some active research was continued at the University of Illinois.

The work to determine the effect of the residual energy stored in different types of radiators and convectors upon the air temperature in a room when the steam supply is turned off has been completed and the results are being compiled in a paper for presentation to the Society. This work was done in the room heating testing plant under conditions approximating those found in actual service. The tests were made with two types of direct cast-iron radiators, two convectors with two types of cast-iron heating units, and two convectors with two types of non-ferrous heating units. The results indicate that there is an appreciable difference in the rate at which the room cools with the different units.

The remodeling of the room heating testing plant for the purpose of providing one large test room 15 ft by 18 ft instead of the two small test rooms 9 ft by 11 ft has been started, and the work is approximately 25 per cent completed. This work will be carried to completion as rapidly as possible.

The work in the warm wall test booth providing for a study of the inlet and outlets of convector heater cabinets with reference to their effect upon the heat output or capacity of the units has been at a standstill for the past year. It is hoped that material progress can be made on this investigation during the next few months and that possibly the project can be completed and the results presented at the next Annual Meeting of the Society.

Technical Advisory Committee IP-10

HEAT TRANSFER OF FINNED TUBES WITH FORCED AIR CIRCULATION

F. B. Rowley, *Chairman*

H. F. Hutzel	R. H. Norris
C. E. Lewis	W. E. Stark
E. J. Lindseth	G. L. Tuve

At its meeting in Chicago in January, the committee approved further plans for research to be carried on at Case School of Applied Science in cooperation with the Research Laboratory during 1936. In accordance with this program, the work has been directed toward the study of dehumidification by cooling surfaces.

To make this study possible, the wind tunnel test equipment at Case School of Applied Science, where the work has been in progress for five years, was therefore further improved to make it possible to produce any wet-bulb-dry-bulb combination ordinarily encountered in comfort cooling, and to accurately control and maintain any desired condition.

A report giving the results of the hundred or more dehumidifying tests made at Case during the year is now being completed and will be published soon. This report indicates that while the work which has been done on this subject to date, including both the results of other investigators and the two papers[a] on this subject previously presented to the Society, is convincing with regard to certain aspects of the problem, there is much yet to be done. Several methods of rating and of calculation have been developed or suggested, but it is important that these be correlated, and that the fundamental laws of surface dehumidification be codified and made a part of the recognized technical equipment of the air conditioning engineer.

The research project sponsored by this committee is therefore proceeding along two lines: (1) experimental determination of the relative accuracy of various methods already in use for expressing the performance of dehumidifying coils; and (2), more accurate analysis of variables, the effects of which are very imperfectly known at present.

The work of the committee has been greatly assisted by active cooperation of the Research Laboratory and of manufacturers and engineers in the industry. Personal contacts have been made with most of the laboratories which have been actively studying this problem in the last two years. A special effort is being made to correlate the present experimental project with the work which has been done by other investigators, mostly outside the Society.

It is hoped that a uniform and simple basis for rating fin-coils and for computing surface heat-transfer may finally be evolved and made a part of the Codes and recommended procedures sponsored by the Society.

Technical Advisory Committee X-11

PSYCHROMETRY

F. R. Bichowsky, *Chairman*

C. A. Bulkeley	F. G. Keyes
J. A. Goff	A. P. Kratz
E. V. Hill	W. M. Sawdon

This committee was appointed during the year to review the psychrometric data now in use and recommend any desirable changes with a view of adopting standard values for general use throughout the industry. The committee has given some consideration to the problem and has organized its work into the following sub-divisions:

(1) *a.* Recommendation of definitions of the various psychrometric quantities including the definition of the standard temperature scale, probably the International scale.

b. The definition of the temperature of the gas which is a matter of some practical importance, since there seems to be a rather common failure to recognize that the thermometer in a gas stream may measure, not the temperature of the gas, but some sort of a mean between the temperature of the gas and the walls.

c. The definition of humidity both relative and absolute. It seems to be most usually forgotten that the usual definition of relative humidity in terms of relative partial volume or partial pressure of water vapor in air has no precise meaning except for a mixture of perfect gases.

d. The definition of dew, total heat, enthalpy, wet-bulb temperature, temperature of adiabatic evaporation, etc.

(2) Pick out standard Psychrometric data. This committee was established after it was determined that the International Committee on Steam Tables had about completed its work. The feeling was that these new Tables would for the first time give an authoritative source of data on the pressure, enthalpy and volume of water vapor. There is comparatively little accurate direct experimental data on the study of air-stream mixtures and it may be that one of the problems of the committee will be to recommend a program for experimental research to fill up this gap. However, it is believed that the increasing knowledge of the equation of the study of mixtures will allow the accurate calculation of psychrometric data for the air-stream mixture on the basis of data on pure steam and pure air. Dr. Keyes, a member of the International Committee on Steam Tables, has been asked to make a preliminary calculation on the source of data and on the method of reduction of data.

(3) Calculate very accurately a few points on the Psychrometric Table to compare with existing tables so as to discover if there are wide discrepancies as have sometimes been claimed. If this preliminary calculation shows that a complete recalculation of the Psychrometric Tables is necessary, the committee will require the services of a skilled calculator since such a complete recalculation is a very large job.

(4) The last function of the committee is to decide on the form of publication of its results, whether in the form of a psychrometric table or whether in the form of a psychrometric chart or charts.

Technical Advisory Committee OH-12

RAILROAD AIR CONDITIONING

A. I. Brown, *Chairman*

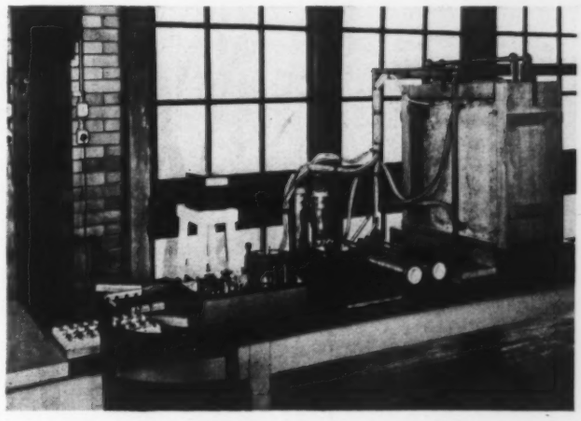
F. E. Giesecke	S. R. Lewis
C. S. Leopold	L. W. Wallace

In recognition of the important place that railroad air conditioning has assumed, this committee was formed this year for the purpose of cooperating with the railroads in any technical studies of railroad air conditioning.

Air conditioning of railroad passenger cars has met with tremendous public approval. There can be no doubt that air conditioning has played an important part in the phenomenal increase in travel by railroad that has occurred during the past year. The experience of traveling in comfort in an air conditioned passenger car even in the hottest of weather has been a revelation to many people and has awakened in their minds the tremendous possibilities of the application of air conditioning for comfort in many fields beyond that of public conveyances. The investment of the railroads of the United States and Canada in air conditioning equipment has now amounted to 45 million dollars. The number of passenger cars that have been air conditioned now totals over 8,000.

Early in the year the Association of American Railroads set up plans for a comprehensive study of air conditioning of passenger cars, under the direction of Mr. L. W. Wallace, Director of the Division of Equipment Research of that Association. This study has proceeded along the following lines:

1. A large amount of factual data has been collected relating to the types and extent of air conditioning equipment being used by the various railroads, the capital investment and maintenance and operating costs.



24 in. hot plate and apparatus as used for testing insulating material at the University of Minnesota

2. A laboratory for testing air-conditioning units was set-up in the Mt. Clare Shops of the Baltimore and Ohio Railroad at Baltimore, Maryland, where tests have been conducted on the various types and makes of air conditioning units used by the railroads. These tests were made in accordance with the Standard Method of Testing and Rating Air Conditioning Equipment proposed by the Joint Committee of the A.S.H.V.E. and the A.S.R.E., and other technical societies.
3. Dynamometer tests of the various driving mechanisms used in the operation of railroad air conditioning equipment have been conducted in the Mechanical Engineering Laboratory of the Ohio State University for the purpose of determining the mechanical efficiency of these mechanisms.
4. Hot room tests of fourteen air conditioned cars have been conducted in the Chicago Plant of the Pullman Standard Car Company. These tests dealt with the determination of the heat insulation value of cars of different type and construction and with the distribution of air and temperatures within the cars, and further served to coordinate measurements of cooling effect in the cars with the results of laboratory and road tests of the air conditioning equipment.
5. A five-day conference of railroad air conditioning engineers was held at Ohio State University early in the summer preparatory to participation in the investigation of air conditions being maintained in passenger cars in service. This conference was attended by engineers from 31 railroads of the United States and Canada on which the road tests were to be conducted.
6. In the road tests the air conditions in nearly 600 passenger cars were measured during 240,000 miles of travel. In response to requests for the opinions of passengers concerning the degree of comfort at the time when the tests were being made, more than 5,000 passengers submitted their comments.

It is hoped that this extensive research will make a valuable contribution to the progress in air conditioning as well as result in added benefit to the traveling public.

Technical Advisory Committee IF-14

CORROSION IN AIR CONDITIONING EQUIPMENT

A. E. Stacey, *Chairman*

M. L. Diver	R. M. Palmer
M. S. Kice	F. N. Speller
F. L. LaQue	C. M. Sterne
C. E. Lewis	R. T. Thornton

H. H. Young

The committee was appointed a little over a year ago to make a study of the prevalence of a corrosion problem in connection with air conditioning equipment. The committee organized, held several meetings, and sent out questionnaires to users of air conditioning equipment to determine the extent to which corrosion was met with and the character of the problems involved.

These questionnaires resulted in definitely proving that there was not a corrosion problem involved in the use of spray type dehumidifiers and coil surfaces, except in certain localities. Water treatment, with service, seems to have satisfactorily solved this problem even in these districts where trouble is otherwise found.

Technical Advisory Committee on

TREATMENT OF AIR WITH ELECTRICITY

C.-E. A. Winslow, *Chairman*

Vannevar Bush	L. R. Koller
W. H. Carrier	C. A. Mills
L. W. Chubb	E. B. Phelps
W. D. Fleming	C. R. Wait
R. F. James	W. T. Wells

This is a new committee appointed during the year to take up the study of a most interesting phase of air conditioning. So far, the committee has only had an opportunity to organize, and hold a meeting January 13 in New York.

Technical Advisory Committee IF-18

AIR CONDITIONING REQUIREMENTS OF GLASS

M. L. Carr, *Chairman*

F. L. Bishop	F. W. Parkinson
A. N. Finn	W. C. Randall
E. H. Hobbie	Cyril Tasker
R. J. Lillibridge	R. A. Miller

G. B. Watkins

This committee was appointed during the year and charged with a study of all problems involving the window and its setting in a building. A meeting of the committee was held in Pittsburgh on September 25, and gave consideration to the following program of research, and approved Item (1) for immediate study:

(1) Heat transfer through glass from air to air, including single, double, and triple glass, and the effect of spacing.
(2) Heat transfer through windows as affected by sash or other accessories of application.
(3) Heat transfer through different types of glass.
(4) Infiltration through windows for all kinds of applications, including weatherstripping.
(5) Solar radiation effects through windows and reduction in this effect by sun arresting appurtenances.
(6) Heat transfer through glass brick walls.
(7) Solar radiation through glass brick walls.

The committee further asked the Research Laboratory to make a survey of possible data available on any phases of the subject as a result of work carried on in the laboratories of manufacturers or elsewhere. In making this survey, the following items should be emphasized:

(1) Find out what unpublished data, if any, on heat loss or transfer through glass, single, double and triple glazing, can be made available to the Research Committee. In this connection, the various glass manufacturing companies and the United States Bureau of Standards should be consulted.
(2) Find out what is being done in various laboratories on the subject that might be made available, in whole or in part, to the Research Committee. Advise with such laboratories as may be willing to cooperate as to scope and methods to be followed, with a view to obtaining data that the Society would be willing to publish in the GUIDE.
(3) Find out where the A.S.H.V.E. Laboratory can carry on research or have research carried on, under its supervision, to obtain such data as may be needed for the GUIDE on the subject of air to air heat transmission through single, double and possibly triple glazed windows.

Technical Advisory Committee IP-20

INTERMITTENT HEATING OF CHURCHES, AUDITORIUMS AND SIMILAR BUILDINGS

E. K. Campbell, *Chairman*

W. L. Cassell	J. M. Robertson
E. F. Dawson	J. H. Kitchen
N. W. Downs	A. H. Sluss

This committee was appointed during the year and charged with a study of the time rate of heating and cooling buildings, together with the extra heat load during the heating up period, in relation to the structure or type of building. The committee has given very serious consideration to a number of directions of attack, including a study of the heat capacity or specific heat of materials commonly used in building structures, and a study of the problem by assuming a given temperature throughout the structure at the beginning of the heating up period, and the surface area and film conductance coefficients for the various walls, partitions, ceilings, and floors adjacent to the heated space.

Technical Advisory Committee IP-21

EFFECT OF ENTERING TEMPERATURE AND VELOCITY ON TEMPERATURE AND DISTRIBUTION OF AIR WITHIN AN ENCLOSURE

Ernest Szekely, *Chairman*

S. H. Downs	C. H. Randolph
M. K. Fahnestock	J. E. Schoen
D. W. Nelson	G. L. Tuve

J. H. Van Alsburg

This committee began the year by continuing to lend its support to the cooperative study carried on under Dean Kartak at Marquette University in cooperation with the Research Laboratory. The lack of personnel other than undergraduate students made it seem futile to obtain worthwhile results on so complicated a problem.

As a result of continued pressure for results in this field, the committee expanded its program in November to include more

intensive studies of the subject at the laboratory of the Barber-Colman Company at Rockford, Illinois, under the supervision of Professor G. L. Larson's Department of the University of Wisconsin, at Professor Larson's Department at the University, and by field observations.

The study at the Barber-Colman laboratory will at first be confined to fundamental observations of an air stream issuing from a plain opening of various sizes, shapes and locations, and with different air stream temperatures and velocities. This will be followed by similar studies with Multiblade type of grilles.

A study will also be carried on at the University of Wisconsin in connection with the system in the new Auditorium. These tests are to simulate those at the Barber-Colman laboratory within the limitations of the equipment, and if feasible will be extended to furnish comparison between the grilles in the side walls and discharge through a perforated ceiling.

The field observations will be made wherever possible. At the present time, the Chairman of the committee and Mr. Randolph have agreed to make certain observations in Milwaukee.

Technical Advisory Committee OH-22

COMFORT REQUIREMENTS FOR SUMMER COOLING

W. L. Fleisher, *Chairman*

A. E. Beals
F. R. Bichowsky
Thomas Chester
F. E. Giesecke
Elliott Harrington
E. V. Hill
R. E. Keyes
Cyril Tasker
C. P. Yaglou

This committee was organized during 1935 to study the cooling requirements for summer comfort air conditioning. A paper was presented to the Society at its Annual Meeting in Chicago, giving the results of a brief study made at the Research Laboratory during the summer of 1935. During 1936 the Committee continued the study at the Laboratory at Pittsburgh and organized additional studies to be carried on by Mr. Tasker of the Ontario Research Foundation at Toronto, Canada, and by Professor Giesecke of the Agricultural and Mechanical College of Texas at College Station, Texas.

The study during 1936 was aimed to determine:

(1) The variation in the cooling requirements for summer air conditioning with different normal summer temperatures in different geographical regions in United States and Canada.
(2) To further indicate the range of temperature, humidity and air motion, or Effective Temperature, allowable for summer cooling.
(3) The allowable variation in relative humidity at a given Effective Temperature.
(4) The variation in the cold shock upon entering a cooled space, and the reaction upon entering the hot outside based upon the Effective Temperature maintained in the conditioned space, and variations in these effects with variation in relative humidity at the same Effective Temperature.
(5) The skin temperature changes upon entering the cooled space from the hot outside, and upon re-entering the hot outside for different Effective Temperatures indoors, and for different relative humidities at the same Effective Temperature.
(6) Allowable air velocities in summer cooling, and particularly, allowable velocities with high moisture content in the air, together with reasons for limiting high velocities; as an example, should such high velocities be limited because of excessive cooling on definite portions of the body, or due to the annoying effect of high velocities in disturbing papers or other materials on which a person may be working; or other more definite sensations of velocity experienced by a person?
(7) The sensation of draft and accompanying lowering of the skin temperature of various parts of the human body due to air velocities or drafts of varying velocities and air stream temperatures at various room temperatures; or in other words, a determination of what constitutes a draft, and the discomfort experienced as a result of the same.

During the summer of 1936 data were collected showing a measurable, although not extremely large, variation in the required temperature for indoor summer cooling as between Pittsburgh and Toronto, Ontario, but no similar change in the requirement as between Pittsburgh and Texas. The three studies indicated that the indoor cooling requirements were based upon Effective Temperatures, and that little variation in comfort was experienced for rather wide variations in relative humidity at a desired Effective Temperature. While some observation was made of the cold shock upon entering a cooled space in relation to the conditions maintained indoors, this phase of the subject requires further study. Items 5 to 7 received little attention during the past summer, and are being continued by the committee, while Item 7, or a study of what constitutes a draft, is being continued throughout both the heating and cooling season of 1937.

The committee has given a great deal of consideration to the general subject of the relation of health and comfort of persons to their atmospheric environment, including both normal and abnormal or diseased persons. The committee has particularly given a great deal of consideration in interesting the medical profession in the use of air conditioning in the treatment of disease. In this connection, the committee was particularly able to cooperate with a number of medical centers, including cooperation between the Laboratory in Pittsburgh and St. Francis Hospital, where the Laboratory, through its past experience in studying the relation between physical reactions of persons to high temperatures, was able to successfully aid in the development of an air-conditioned "fever therapy box," now being used at the St. Francis Hospital. A paper[12] on the development of this box is being presented at the Annual Meeting in St. Louis.

Technical Advisory Committee IF-23

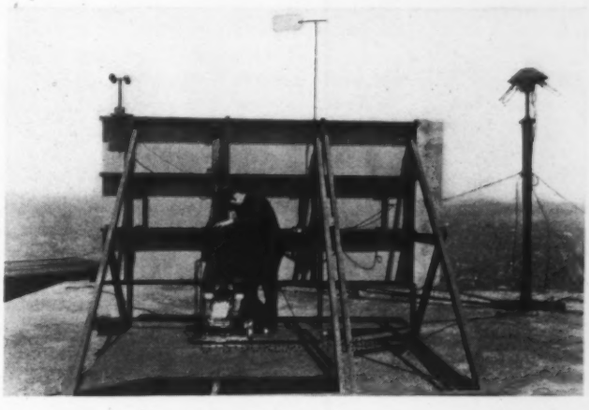
INSULATION

L. A. Harding, *Chairman*

E. A. Allcut
J. D. Edwards
E. C. Lloyd
R. T. Miller
E. R. Queer
T. S. Rogers
F. B. Rowley
W. S. Steele
Cyril Tasker
B. Townshend
G. B. Wilkes

This committee was appointed during the year and charged with the making of a survey of the entire subject involving the testing and reporting of heat transfer values for, and the economic usage, of insulation. After organization, eleven members of the committee met with the Chairman of the Committee on Research and the Director of the Research Laboratory in Buffalo, N. Y., for an all day session.

The committee first agreed that the Society's present code for testing building insulation material for heat transfer needed revision to bring it up to date, and a sub-committee consisting of Professors Rowley, Allcut, Wilkes, Queer, and Mr. Houghten was appointed and asked to report back to the main committee.



Studying wind velocity gradient near a wall by the Research Laboratory, A.S.H.V.E., Pittsburgh

The committee further gave consideration to the following questions concerning the usage of insulation, but deferred until a later date in making recommendations concerning the need for study of any of the particular subjects mentioned or concerning their order of importance.

(1) The effect of "regain moisture" on the conductivity of insulating materials.
(2) The effect of condensed moisture on the conductivity of insulating materials in a structure.
(3) Effect of the thickness of an insulating material accepted for test on the conductivity value obtained.
(4) Effect of condensation on the surface of reflective insulation.
(5) Effect of fibre size and fibre arrangement within an insulating board on its conductivity.
(6) To what extent do radiation, convection and conduction play a part in the transfer of heat through an insulating material.
(7) Relation between the heat capacity of an insulating material on the rate of heat penetration through a structure in which it is installed.
(8) The degree of settling found for different "fill" materials after it is placed in the structure.
(9) The relation between the conductivity of "fill" insulating material and the density of the pack—What is the optimum density and lowest conductivity?
(10) Effect of sealing cracks around windows and doors in order to keep infiltering air out of spaces containing insulating materials on the heat transfer through the structure.
(11) Relation between the physical characteristics of the material as regards the capillary properties of the fibres in the structure and its behavior in use.
(12) A further study of the film conductance coefficients for air spaces, particularly where reflective surface insulation is used. Such studies should be made with a view of separating heat transfer to or from a surface by radiation and convection.
(13) Film conductance and air space coefficients should be given for both horizontal and vertical surfaces.
(14) Effect of radiation from hot metallic or other types of surfaces in a hot-plate testing apparatus on the conductivity value obtained for different types of materials. This may account for apparent discrepancies in conductivity values obtained for different materials by different investigators using different apparatus.
(15) Study of heat transfer through walls containing insulating materials in small electrically heated test houses.
(16) More emissivity values should be determined for different materials and tabulated in the GUIDE.
(17) The corrosion action of insulation materials in the presence of moisture on other materials, including metals used in the structure.
(18) The adaptability and performance characteristics of insulation when applied to the modernization of older buildings.
(19) A study of the characteristics of insulation after long service in a structure.
(20) More information on the effect of applying insulating material of a given thickness having given conductivity characteristics to a structure.
(21) Effect of expansion or contraction and other physical changes in a building on the performance of insulating materials used in connection therewith.

Technical Advisory Committee X-24

CLIMATE AND ITS RELATION TO AIR CONDITIONING FUNDAMENTALS

Dr. C. A. Mills, *Chairman*

G. C. Dunham — C. F. Neergaard
James Govan — F. M. Pottenger, Jr.
Dr. W. J. McConnell — E. L. Weber
C.-E. A. Winslow

This committee, appointed during the year, is engaged in organization and the development of a program. An attempt is being made by mail to gather opinions from the members as to the major problems to be faced.

It is well agreed that much basic data yet remain to be collected on the physiologic response to physical environment before air-conditioning can be put on a firm and lasting footing. Some feel that quite radical alterations must be made in conditioning methods, and even principles, before wholly satisfactory results can be obtained. Closer investigation should be made of the use of radiant heat for comfort conditioning for both winter and summer. The physiologic effects of storm fluctuations in barometric pressure must be investigated, for there are strong hints that pressure control may before long be deemed of importance second only to control of temperature.

It seems imperative that the Society, through its Committee on Research, make every effort to speed up studies dealing with the fundamentals of air conditioning in the immediate future, so as to be better prepared for the period of marked expansion that lies in the years just ahead. Knowledge of the response of normal individuals to environment seems more important in this respect than does that obtained from the sick, since the major expansion of air conditioning will be in buildings occupied by normal individuals.

Technical Advisory Committee IF-26

ATMOSPHERIC IMPURITIES AND RESULTING SAFETY AND HEALTH REQUIREMENTS

Theodore Hatch, *Chairman*

J. J. Bloomfield — Philip Drinker
C. A. Booth — Dr. Leonard Greenburg
H. B. Meller

So far, the work of this committee has been limited to a survey of the problem and the study of the different organizations interested in it. A meeting of the committee is being arranged for the near future.

During the past year there has been a great increase in the number of states offering technical services in industrial hygiene and at the present time 19 such bureaus are in existence. At least one engineer is attached to each office. There are also in existence several important active committees engaged in reviewing and studying the problem. Among these may be mentioned:

1. Safety Code Committee on Exhaust Systems, American Standards Association (Several sub-committees have been formed to prepare codes for different processes, one to prepare report on Fundamentals relating to Exhaust Systems).
2. Advisory Committee on Toxicity of Dusts and Gases, American Standards Association.
3. Preventive Engineering Committee, Air Hygiene Foundation of America, Inc. (The preliminary report of this committee recommends certain research problems to the Directors of the Air Hygiene Foundation.)
4. Committee on the Prevention of Silicosis through Engineering Control. National Conference on Silicosis and Similar Dust Diseases. (This committee has several sub-committees engaged in preparing reports on the many different phases of the problem. The main report will be available soon.)
5. Committee on Ventilation and Atmospheric Pollution, American Public Health Association (Part 11, including several sub-committees, has to do with standard methods for the examination of the air; determination of dust, bacteria, gases and thermal factors affecting human comfort. Reports from this committee are already in print).

These activities indicate a growing realization of the need for the development of fundamental engineering methods of design to care for greater numbers of hazardous industrial processes. With respect to the functions of the present committee, it is essential that the problems in the field be carefully reviewed, that the work performed by existing committees be studied, and that the opportunities for cooperation with these committees be investigated, in order to make certain that the program adopted will yield the most useful results and not cause duplication of effort.

The general objectives of the committee include:

1. Collection and evaluation of existing published data pertaining to the industrial dust control problem.
2. Outlining and guiding fundamental research problems by the Society.
3. Fostering field studies for the collection of basic engineering data.
4. Action to bring about the preparation and publication of more technical papers in this field. A great deal of valuable engineering work is being done in industrial establishments, but very little of this is described in technical journals in a form that is helpful to others.

Research Laboratory — A. S. H. V. E.

Statement of Income and Expenses

(Year Ending December 31, 1936)

INCOME

	Budget 1936	Actual 1936
1. Balance from 1935 Committee	$ 8,178.62	$ 8,178.62
2. Dues—Current and Prior Years	11,500.00	.....
3. Guide	1,500.00	.....
4. Heating and Ventilating Exposition	2,500.00	6,828.85
5. Interest on Bank Balances	30.00	31.46
6. Interest on Savings Account.	70.00	63.76
7. Interest on Society Endowment	400.00	600.00
8. Contributions—Earmarked	.....	1,425.00
9. Contributions—General	.....	100.00
10. Special Council Appropriation	.....	4,000.00

EXPENDITURES

	Budget 1936	Actual 1936
1. Travel	$ 1,200.00	$ 1,370.65
2. Salaries—Laboratory Staff	9,500.00	8,760.87
3. Salaries — Part-time Student Help	1,500.00	1,491.30
4. Cooperative Research — General	2,675.00	1,012.50
5. Cooperative Research — Earmarked	1,425.00	1,193.75
6. Cooperative Research — Med. School	1,800.00	1,800.00
7. Office Supplies and Expense.	400.00	585.86
8. Laboratory Supplies and Equipment	700.00	476.61
9. Exhibits, Meetings, etc.	400.00	374.13
10. Printing and Promotion	400.00	40.00
11. Correlating Thermal Research	600.00	600.00
12. Salary—Office of Chairman.	900.00	882.82
13. Promotion — Financial Campaign	2,500.00	701.10
14. Contingency Fund	500.00	.....
TOTALS	$24,500.00	$19,289.59
Unappropriated Balance	3,678.62	
	$28,178.62	

Research Contributors — 1936

Funds and Equipment

Aerofin Corp.
American Air Filter Co.
Barber-Colman Co.
Bryant Heater Co.
Canada Vulcanizer & Equipment Co.
Canadian General Electric Co., Ltd.
Carrier Corp.
Chamberlin Metal Weatherstrip Co.
Chicago Master Steamfitters Assn.
Clarage Fan Co.
Detroit Edison Co.
C. A. Dunham Co., Ltd.
Edison Electric Illuminating Co. of Boston
Fairbanks-Morse Co.
Julien P. Friez & Sons, Inc.
Frigidaire Corp.
General Electric Co.
Gilbert & Barker Mfg. Co.
Heating, Piping & Air Cond. Contractors National Assn.
Hoffman Specialty Co.
Johnson Service Co.
Johns-Manville Co.
Kelvinator Corp.
Kroeschell Engrg. Corp.
P. H. MaGirl Foundry & Fur. Wks.
McDonnell & Miller
Meyer Furnace Co.
Minneapolis-Honeywell Regulator Co.
Minneapolis-Honeywell Regulator Co., Ltd.
Mueller Brass Co.
National Warm Air Heating & Air Conditioning Assn.
Nash Engrg. Co.
J. J. Nesbitt, Inc.
New York Steam Corp.
Philadelphia Electric Co.
Portland Cement Assn.
Rochester Gas & Electric Corp.
Rome-Turney Radiator Co.
Stannard Power Equipment Co.
Trane Co.
Tuttle & Bailey Co.
Union Electric Light & Power Co. of St. Louis
Ventilating & Air Conditioning Contractors Assn. of Chicago.
Westinghouse Electric & Mfg. Co.
Westinghouse Electric Co., Ltd.
L. J. Wing Mfg. Co.
Young Radiator Co.
York Ice Machinery Corp.

A. S. H. V. E. Officers Elected in 1937

D. S. Boyden
Boston, Mass.
President

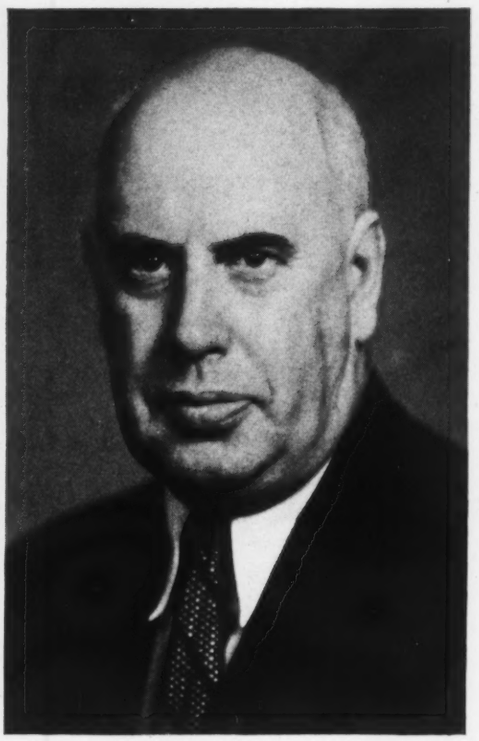
E. H. Gurney
Toronto, Can.
First Vice-President

J. F. McIntire
Detroit, Mich.
Second Vice-President

Alfred J. Offner
New York, N. Y.
Treasurer

Council Members Elected for Three-Year Term

J. J. AEBERLY
Chicago, Ill.



M. C. BEMAN
Buffalo, N. Y.

E. O. EASTWOOD
Seattle, Wash.

W. A. RUSSELL
Kansas City, Mo.

NEWS OF LOCAL CHAPTERS

OFFICERS OF LOCAL CHAPTERS—1937

CLEVELAND: *Organized,* 1916. *Headquarters,* Cleveland, O. *Meets,* Second Thursday in Month. *President,* L. T. AVERY, 2341 Carnegie Ave. *Secretary,* W. R. BEACH, 75 Public Sq.

CINCINNATI: *Organized,* 1932. *Headquarters,* Cincinnati, O. *Meets,* Second Tuesday in Month. *President,* E. B. ROYER, 6635 Iris Ave. *Secretary,* K. W. SCHICK, 561 Reading Rd.

ILLINOIS: *Organized,* 1906. *Headquarters,* Chicago. *Meets,* Second Monday in Month. *President,* J. J. HAYES, 53 W. Jackson Blvd. *Secretary,* C. E. PRICE, 6 N. Michigan Ave.

KANSAS CITY: *Organized,* 1917. *Headquarters,* Kansas City, Mo. *Meets,* Second Monday in Month. *President,* L. R. CHASE, 2440 Pennway. *Secretary,* F. J. DEAN, JR., 6028 Walnut St.

MANITOBA: *Organized,* 1935. *Headquarters,* Winnipeg, Man. *Meets,* Fourth Thursday in Month. *President,* J. B. STEELE, 184 Waterloo St. *Secretary,* C. H. TURLAND, 325 Centennial St.

MASSACHUSETTS: *Organized,* 1912. *Headquarters,* Boston. *Meets,* Second Tuesday in Month. *President,* JAMES HOLT, Massachusetts Institute of Technology, Cambridge, Mass. *Secretary,* JOHN TURNER, 285 Columbus Ave.

MINNESOTA: *Organized,* 1918. *Headquarters,* Minneapolis. *Meets,* Second Monday in Month. *President,* N. D. ADAMS, 220 Second Ave. S. W., Rochester, Minn. *Secretary,* J. E. SWENSON, 800 Hennepin Ave.

MICHIGAN: *Organized,* 1916. *Headquarters,* Detroit. *Meets,* First Monday after the 10th of the Month. *President,* R. K. MILWARD, 127 Campbell Ave. *Secretary,* G. H. TUTTLE, 2000 Second Ave.

WESTERN MICHIGAN: *Organized,* 1931. *Headquarters,* Grand Rapids. *Meets,* Second Monday in Month. *President,* L. G. MILLER, Mich. State College, E. Lansing, Mich. *Secretary,* E. I. ADAMS, 115 So. Pine, Lansing, Mich.

MONTREAL: *Organized,* 1936. *Headquarters,* Montreal, Que. *Meets,* Second Monday in Month. *President,* G. L. WIGGS, University Tower. *Secretary,* C. W. JOHNSON, 630 Dorchester St., W.

NEW YORK: *Organized,* 1911. *Headquarters,* New York. *Meets,* Third Monday in Month. *President,* G. E. OLSEN, 101 Park Ave. *Secretary,* T. W. REYNOLDS, 100 Pinecrest Dr., Hastings-on-Hudson, N. Y.

WESTERN NEW YORK: *Organized,* 1919. *Headquarters,* Buffalo. *Meets,* Second Monday in Month. *President,* P. S. HEDLEY, Curtiss Bldg. *Secretary,* C. A. GIFFORD, 247 North Dr.

OKLAHOMA CITY: *Organized,* 1935. *Headquarters,* Oklahoma City, Okla. *President,* F. X. LOEFFLER, 1604 N. W. Fifth St. *Secretary,* E. W. GRAY, Box 1498.

ONTARIO: *Organized,* 1922. *Headquarters,* Toronto, Ont. *Meets,* First Monday in Month. *President,* THOMAS MCDONALD, 117 Peter St. *Secretary,* H. R. ROTH, 57 Bloor St. W.

PACIFIC NORTHWEST: *Organized,* 1928. *Headquarters,* Seattle, Wash. *Meets,* Second Tuesday in Month. *President,* S. D. PETERSON, 473 Colman Bldg. *Secretary,* D. C. GRIFFIN, Orpheum Bldg.

PHILADELPHIA: *Organized,* 1916. *Headquarters,* Philadelphia. *Meets,* Second Thursday in Month. *President,* W. F. SMITH, 422 Bryn Mawr Ave., Cynwyd, Pa. *Secretary,* H. H. ERICKSON, 804 Architects Bldg.

PITTSBURGH: *Organized,* 1919. *Headquarters,* Pittsburgh. *Meets,* Second Monday in Month. *President,* M. L. CARR, P. O. Box 1646. *Secretary,* T. F. ROCKWELL, Carnegie Inst. Tech.

ST. LOUIS: *Organized,* 1918. *Headquarters,* St. Louis. *Meets,* First Tuesday in Month. *President,* C. R. DAVIS, 2328 Locust St. *Secretary,* R. J. TENKONOHY, 3650 Shaw Blvd.

SOUTHERN CALIFORNIA: *Organized,* 1930. *Headquarters,* Los Angeles. *Meets,* Second Tuesday in Month. *President,* LEO HUNGERFORD, 524 Loew's State Bldg. *Secretary,* H. M. HENDRICKSON, 5051 Santa Fe Ave.

TEXAS: *Organized,* 1936. *Headquarters,* College Station, Texas. *President,* F. E. GIESECKE, Texas A. & M. College. *Secretary,* W. H. BADGETT, Texas A. & M. College.

WASHINGTON, D. C.: *Organized,* 1935. *Headquarters,* Washington, D. C. *Meets,* Second Wednesday in Month. *President,* W. A. DANIELSON, 2236 Munitions Bldg. *Secretary,* M. D. KICZALES, 3000 Connecticut Ave., N. W.

WISCONSIN: *Organized,* 1922. *Headquarters,* Milwaukee. *Meets,* Third Monday in Month. *President,* M. E. ERICKSON, 8405 W. Greenfield Ave., West Allis, Wis. *Secretary,* R. G. KOCH, 626 E. Wisconsin Ave.

Kansas City Discusses Energy Consumption in Air Conditioning Plants

December 14, 1936. Twenty-seven members were present for dinner and six additional members attended the meeting of Kansas City Chapter at the Newbern Hotel.

Pres. L. R. Chase discussed the Society's Annual Meeting in St. Louis, January 25-27, and suggested that a group of Kansas City members arrange to make the trip in a private car.

The possibility of joint action with the Engineers Club and local members of national societies in promoting a bill for licensed engineers in Missouri was discussed by Pres. Chase.

A. D. Marston, Kansas City Power and Light Co., was the speaker of the evening and was introduced by Pres. Chase. Mr. Marston spoke on Energy Consumption by Air Conditioning Plants, a topic of unusual interest due to the nature of the data presented.

Mr. Marston had compiled figures on the energy consumption of the majority of air conditioning plants in Kansas City during the years 1934, 1935 and 1936. From a study of these figures, copies of which were distributed to those present at the meeting, Mr. Marston arrived at a method of comparing energy consumption in summer air conditioning plants with the number of degree days above a base figure of 65 deg. This information is of value to power companies which are interested in the future of air conditioning electrical consumption. Mr. Marston also presented data as to the number of kilowatt hours per connected horse power required for different types of air conditioning systems.

Secy. F. J. Dean, Jr., reports that the meeting adjourned after a short discussion.

Philadelphia Chapter Enjoys Social Meeting

January 14, 1937. The annual social meeting of the Philadelphia Chapter was held at the Hudson Recreation Center and 60 members and their guests were present.

The usual business and the reading of the minutes were omitted.

C. B. Eastman, chairman of the Meetings Committee, provided an excellent Dutch Lunch, after which everyone indulged in the arduous sport of bowling.

According to Secy. H. H. Erickson, the outing was enjoyed by everyone present.

Montreal Chapter Has Guest Speakers

December 14, 1936. Forty members and guests of the Montreal Chapter met at the Windsor Hotel, and following dinner the meeting was called to order at 7:30 p. m. by Pres. G. L. Wiggs.

After a discussion, it was voted to schedule the dinner which precedes the regular meetings at 6:00 p. m.

Cyril Tasker, Ontario Research Foundation, Toronto, was the guest of honor and speaker of the evening. Mr. Tasker was introduced by President Wiggs and gave an illustrated talk on Cooling Requirements for Summer Comfort Air Conditioning.

A vote of thanks to Mr. Tasker was extended by F. R. Barnsley on behalf of the Chapter before the meeting adjourned at 10:15 p. m.

November 9, 1936. Following dinner the second meeting of the Montreal Chapter was called to order at 7:30 p. m. in the Windsor Hotel by Pres. G. L. Wiggs. Approximately 80 members and guests were present.

W. L. Fleisher, consulting engineer, New York, was introduced

by President Wiggs and spoke on Evaporative Cooling for Comfort, which was followed by general discussion.

The minutes of the previous meeting were read by Secy. C. W. Johnson and approved.

Treasurer F. G. Phipps announced to Chapter members that notices would be sent out immediately requesting payment of local chapter dues at an early date.

A vote of thanks was extended to Mr. Fleisher by A. W. Givin on behalf of the Chapter.

October 14, 1936. The first regular meeting of Montreal Chapter was attended by 70 members and guests at the Windsor Hotel.

Following dinner, Pres. G. L. Wiggs called the gathering to order and the minutes of the previous meetings were read and accepted.

J. A. M. Robertson, Jr., reported for the Montreal Chapter Constitution Committee, and it was voted that the Constitution be accepted as read.

A discussion was called relative to the permanent slate of officers for the ensuing year, and it was voted to retain the present officers.

J. I. Lyle, past-president of the A. S. H. V. E., was introduced by President Wiggs, and spoke briefly on Chapter Membership Benefits.

President Wiggs called on Secy. C. W. Johnson to introduce the honored guest and speaker of the evening, Prof. G. L. Larson, Madison, Wis., president of the A. S. H. V. E. President Larson addressed the meeting on The Economics of Good Construction as Related to Residential Heating, and his talk was followed by a general discussion.

A brief talk on Research Activities and Program of the A. S. H. V. E. was given by A. V. Hutchinson, secretary.

Nominations for the fourth member of the Board of Governors were in order and resulted in the election of Leo Garneau.

A vote of thanks to President Larson was extended by F. Hankin, and the meeting adjourned at 10 p. m.

Pittsburgh Holds Air Conditioning Symposium

January 11, 1937. Pres. M. L. Carr called the meeting of Pittsburgh Chapter to order in the U. S. Bureau of Mines and 42 members and guests were present.

After the minutes of the December meeting had been read and approved, President Carr announced the following committee appointments for 1937:

Program Committee—J. F. S. Collins, Jr., *Chairman,* R. H. Heilman, R. A. Miller, John Proie, E. C. Smyers.

Membership Committee—P. A. Edwards, *Chairman,* F. C. McIntosh, L. S. Maehling, E. H. Reismeyer, Jr., R. B. Stanger.

Attendance and Social Committee—E. S. Tower, *Chairman,* P. C. Strauch, V. A. Reed, Jr., Charles Sonneborn, R. J. J. Tennant.

Committee on Code for Installation of Air Conditioning—Geo. S. McEllroy, *Chairman,* P. A. Edwards, F. C. Houghten, G. G. Waters.

Degree-Day Committee—F. A. Gunther, *Chairman,* J. F. S. Collins, Jr., and F. C. Houghten.

Committee on Air Pollution—M. I. Dorfan, *Chairman,* T. G. Estep, J. Earl Frazier, J. H. Holden.

Current Events Committee—T. F. Rockwell.

Chairman Collins of the Program Committee stated that the Symposium on Air Conditioning an Office Building would be continued at the February meeting.

Chairman Edwards reported one new application for membership.

Mr. Tennant, chairman of the Board of Governors, reported the following recommendations of the Board: (1) that the bills for chapter dues for 1937 be mailed and that dues be collected; (2) that the next few meetings be held in the downtown district of the city.

President Carr turned the meeting over to Mr. Tennant who directed the Symposium on Air Conditioning and outlined the scope of the problem as follows: An office building of floor plan and construction similar to the Grant Building is proposed to be constructed to a height of eight stories in downtown Pittsburgh. It is proposed to install equipment for complete year round air conditioning in all offices. Various members of the Chapter have consented to study the several phases of the problem and make recommendations to the owner and his consulting engineer.

Mr. Tennant then introduced Mr. Collins who presented the results of the heat loss and heat gain calculations and described briefly the assumptions and method used in making the calculations. Following this the audience thoroughly discussed the calculations and recommended several changes in the heat gain calculations.

H. A. Cannon was then introduced and analyzed the space and air distribution problems. Mr. Cannon's analysis was extensive and after a brief discussion, the meeting adjourned at 10:50 p. m., according to the report of Secy. T. F. Rockwell.

Southern California Chapter Honors W. H. Carrier

December 8, 1936. Southern California Chapter held its regular meeting at the Rosslyn Hotel Tuesday noon with luncheon served at 12:15 p. m. President Leo Hungerford presided and 25 members and guests were present.

O. W. Ott, chairman of the Chapter's Research Committee, was called upon to report on the progress of the work which had been discussed at the November meeting. Mr. Ott stated that Dr. B. M. Woods had forwarded a letter describing in detail the research program planned at the University of California, at Berkeley.

As the date of this meeting coincided with the 25th anniversary of the presentation of the rational psychrometric data to the engineering profession by W. H. Carrier, the meeting was dedicated to his honor. President Hungerford gave a talk on the subject of Mr. Carrier's contribution to the air conditioning industry, in which he outlined Mr. Carrier's life and discussed his various contributions to the science of air conditioning.

Secy. H. M. Hendrickson has reported that the meeting adjourned promptly at 1:30 p. m.

Cooling Standards and Hospital Air Conditioning System Discussed at Washington, D. C., Meeting

January 12, 1937. Washington, D. C. Chapter held its regular meeting at the Army Medical Center, and there were 45 members and guests present at the dinner and 100 attended the meeting following.

The regular business meeting was called to order at 8:00 p. m. in the lecture hall by Pres. W. A. Danielson, and the minutes of the preceding meeting were read and approved.

A telegram from Pres. C. R. Davis, of the St. Louis Chapter, invited members of Washington, D. C. Chapter to the Society's Annual Meeting in St. Louis, January 25-27.

A letter was read from W. H. Carrier, expressing appreciation of the good wishes of Washington Chapter conveyed to him on the occasion of the Silver Anniversary of his initial efforts in the air conditioning field.

On motion duly made and carried, it was resolved that the Chapter take no action on the matter of national chapter membership dues as set forth in the resolution of the Cleveland Chapter.

President Danielson introduced F. C. Houghten, director of the A. S. H. V. E. Research Laboratory, Pittsburgh, Pa., who spoke on the subject of Cooling Requirements for Summer Comfort Air Conditioning. With the aid of lantern slides Mr. Houghten carefully explained the work done by the Society in obtaining more data on comfort conditions. The information obtained was the result of tests conducted at Toronto, Canada.

at the Engineering Experiment Station of the Agricultural and Mechanical College of Texas, and at the Research Laboratory at Pittsburgh.

F. M. Thuney, E. V. Fineran and Dr. Bernton led the general discussion from the floor and Mr. Houghten very ably answered all questions relative to this work.

C. R. Seckinger, Office of The Quartermaster General, was introduced by President Danielson and spoke briefly on the methods of design used and the operation of the air conditioning system in the vaccine cubicles in the Medical School of the Army Medical Center. Mr. Seckinger then conducted the members and their guests on an inspection of the actual installation showing how the air is filtered, cooled, dehumidified, and finally sterilized by a bank of violet ray lamps.

W. L. Keplinger was presented and outlined the method of design and controls used in the air conditioning system in the hospital's operating room and recovery wards. The members and their guests also inspected this system.

There being no further business, Secy. M. D. Kiczales reports that the meeting adjourned at 10:45 p. m.

Air Conditioning Provides Interesting Discussion at Illinois Meeting

January 11, 1937. A meeting of the Illinois Chapter was held at the Hotel Sherman and 110 members and guests were present. Pres. J. J. Hayes called the meeting to order at 8:00 p. m. and the minutes of the previous meeting were read and approved. Secy. C. E. Price then announced the details of the special train arranged for the trip to St. Louis for the Annual Meeting of the Society. Telegrams from C. R. Davis, president of the St. Louis Chapter, and from Prof. G. L. Larson, president of the A. S. H. V. E., were read, cordially inviting Illinois members to the Annual Meeting.

Tom Brown, chairman of the Membership Committee, announced the applications of B. P. Adams, George LaRoi, J. E. McDonnell, N. W. Swanson and E. H. Wendt, who were formally welcomed into the Chapter.

The customer's opinion of air conditioning—its advantages and disadvantages, was presented by H. J. Rogan, assistant chief engineer, the Estate of Marshall Field, under the title of Building Owning Industry Views Air Conditioning Industry. After describing the set-up of his organization as representative of the building owning industry, he explained that space was his commodity and his business depended upon selling it and keeping it sold. To do this the building owner will do everything practicable—even air condition.

Essential in their order of operating cost are cleaning, elevators, heating, plumbing, electricity and ventilation. Not required by the average but peculiar to certain tenants are such services as process steam, private elevators, etc.

The owner is happy to see air conditioning go in for the tenant who wants it and is willing to pay for it. It gives the tenant a personal interest in his space. Handicaps, though, exist. Power is not normally available near rentable area. The same is true of steam, water and waste. The obvious solution to the water and waste problem, in Mr. Rogan's opinion, is the use of evaporative condensers. The point, however, is that these costs involved must be figured against the space which in turn must be figured from a five-year lease viewpoint and not a 50-year building life. Mr. Rogan feels that some air conditioning salesmen overlook this, as well as air conditioning engineers.

The owner also considers any investment from the viewpoint of higher utilization. Will it make available space that otherwise could not be rented because it is undesirable? The audience was asked to answer that insofar as air conditioning is concerned.

Another yardstick of the owner in making an investment is the protection of potential income. If air conditioning does that, Mr. Rogan stated that there would be no hesitation in its expense.

The speaker felt that the introduction of air conditioning to many office buildings was not sound because it is coming in the form of scattered installations throughout a building and the owner may soon find the office building with many machine rooms. Having in mind the protection of the owner's potential income Mr. Rogan felt that the best such protection is in the installation of a central system.

The central system brings up the question of recirculated air, and Mr. Rogan felt that its advantages are being overstressed by our industry. He found fault, too, with the Chicago code provision which requires a fixed volume of outside air, on the basis that he could not satisfy the requirements and temperaments of several different tenants on a single fan system delivering a fixed quantity of air. He has tried and failed.

He then asked if varying the volume of air to suit room requirements was unsound in theory as it is commonly practiced in New York, Philadelphia and Washington.

In the discussion which followed, J. J. Aeberly maintained the position that there must be a minimum requirement for air volume, to which Mr. Rogan replied that there are points of satisfaction below the minimum demanded by Chicago laws. E. P. Heckel agreed that there must be a minimum against which to design, though in operation it may be too low in some cases and too high in others. He pointed out that in varying volumes and air motion there is a change in the effective temperature. H. M. Hart observed that it is impossible to anticipate occupancy when designing, so there must be laws for design. In operation this could be adjusted, he felt. In other discussion it was pointed out that it is impossible to reach 100 per cent and that the comfort chart is based on 95 per cent of the subjects; that, as Mr. Blaker stated, progress in equipment and methods was constantly being advanced and the problems Mr. Rogan presented will find their solution.

The meeting adjourned at 10:15 p. m. according to the report of Secy. Price.

Controls Subject of Cleveland Meeting

January 11, 1937. Secy. W. R. Beach reports that 120 members and guests attended the January meeting of Cleveland Chapter which was preceded by a dinner at which 46 were present.

H. M. Nobis, treasurer, asked for payment of local chapter dues, and R. A. Wilson reported for the Membership Committee. A brief outline of plans for the February meeting was given by M. F. Rather of the Entertainment Committee.

Prof. G. L. Tuve spoke for the Education Committee, and F. A. Kitchen reported for the Legislation Committee.

The Society's Annual Meeting in St. Louis, January 25-27, was brought to the attention of the meeting by W. E. Stark, and it was found that six or eight Cleveland members planned to attend. It was moved, seconded and unanimously passed that a formal invitation be extended to the A. S. H. V. E. to hold their Annual Meeting and Exposition in Cleveland in 1938.

F. A. Rodgers then took charge and outlined meetings scheduled for the coming months: March—Tomorrow's Air Conditioning, April—Medical Meeting, May—Air Conditioning Plant Design, and June—Election of officers.

Mr. Rodgers then introduced A. B. Newton, assistant chief engineer in charge of Control Design Application, Minneapolis-Honeywell Regulator Co., who spoke in place of G. D. Kingsland who was unable to be present because of illness.

Mr. Newton pointed out that equipment designed today is usually for the heaviest load condition with very little attention paid to light load conditions. Many applications have very little weather load, but practically all internal load, requiring different control than when a heavy external heat load is encountered. The common control system operates with a sensible to latent heat ratio of about 3.6. Combination of dry bulb and relative humidity control is desirable; also the automatic control of outside air, commonly known as an economizer control, makes for

economical operation when 100 per cent outside air supply is possible.

Mr. Rodgers then introduced M. F. Rather, Johnson Service Co., who spoke in place of Mr. Otto who was unable to attend on account of illness. Mr. Rather gave an interesting outline of thermostat and hygrostat sensitive elements, thermostatic valves, dampers, etc. He described in detail the type of operation that could be obtained from reset controls.

An interesting discussion followed. Mr. Rodgers pointed out that the control system should be designed with the air conditioning system, and vice versa, because if units are not balanced accurate control becomes practically impossible.

Philip Cohen asked about preheat coil control on heating and about high temperature and high humidity control, which questions were answered by various people.

Mr. Fenwick brought up the matter of control costs in proportion to the total air conditioning installation cost, and it was agreed that the control cost was becoming an appreciable item.

L. T. Avery inquired about effective temperature control. Mr. Newton said this was satisfactorily accomplished by means of a dual thermostat and humidistat control.

The meeting was adjourned at 10:45 p. m.

Ontario Chapter Reviews Research Paper

January 11, 1937. A joint meeting of the Ontario Chapter of the *A.S.H.V.E.* and the Ontario Chapter of the *A.S.M.E.* was held on January 11 at the Royal York Hotel. Ninety-eight members and guests were present for dinner.

Pres. Thomas McDonald called on Dr. Speakman, who described the object of the Ontario Research Foundation.

Mr. Ball, chairman of the *A.S.M.E.*, introduced the principal speaker of the evening, C. Tasker of the Ontario Research Foundation who gave an illustrated talk on "Cooling Requirements for Summer Comfort Air Conditioning." Following Mr. Tasker's address, there was a very interesting discussion.

Prof. E. A. Allcut extended a vote of thanks to the speaker for his address.

CANDIDATES FOR MEMBERSHIP

The Constitution of the Society, as now amended, requires the following mode of procedure in voting on applicants for membership in the Society. All applications for membership are to be sent to the Secretary and the names of applicants and their references shall be printed in the next issue of the JOURNAL of the Society or sent to the members in other approved manner as ordered by the Council. When replies are received from references, the Candidate's application shall be submitted to and acted upon by the Committee on Admission and Advancement as soon as possible.

When the Committee on Admission and Advancement has acted favorably upon a Candidate's application and assigned his grade, the Council shall vote upon the election of the proposed Candidate for membership by letter ballot. During the past month 44 applications for membership have been received and the names of these men and their sponsors are published in the following list.

Members are requested to scrutinize the list with care. The Committee on Admission and Advancement, and in turn the Council, urge the members to assume their share of responsibility of receiving these candidates into membership by advising the Secretary promptly of any whose eligibility for membership is in any way questioned.

All correspondence in regard to such matters is strictly confidential, and is solely for the good of the Society, which it is the duty of every member to promote.

Unless objection is made by some member by February 15, 1937, these candidates will be ballotted upon by the Council. Those elected to membership will be notified by the Secretary immediately after election.

CANDIDATES	REFERENCES	
	Proposers	*Seconders*
BOWERMAN, E. L., Sales Engr., Canadian General Elec. Co., Ltd., Toronto, Ont., Can.	J. W. O'Neill J. H. Fox	Thomas McDonald W. D. Gordon
CAMPBELL, G. S., Air Cond. Engr., Tenn. Elec. Power Co., Nashville, Tenn.	C. E. Lewis A. R. MacMillan	Albert Buenger J. G. Clarke
CASE, D. V., Mgr., B. D. R. Materials, Inc., Kansas City Mo.	J. H. Carter T. H. Anspacher	D. D. Zink W. A. Russell
CLINE, E. A., Sales Engr., Air Cond. Co., Los Angeles, Calif.	Leo Hungerford H. B. Lauer	E. H. Kendall A. H. Simonds
COLFORD, JOHN, Pres., John Colford, Ltd., Montreal, Que., Can.	T. E. McGrail G. L. Wiggs	C. W. Johnson F. G. Phipps
CROSS, R. C., Fuel Engr., Battelle Memorial Inst., Columbus, Ohio.	R. A. Sherman A. I. Brown	W. A. Welcker (*A.S.M.E.*) E. W. Seckendorff (*A.S.M.E.*)
DE SOMMA, A. E., Jr., Engr., L. J. Wing Mfg. Co., New York, N. Y.	H. S. Wheller A. E. Seelig	C. L. Meyer Wallace Preston (*Non-Member*)
FARROW, H. L., Engr., Air Cond. Engrg. Co., Cambridge, Mass.	G. B. Gerrish M. G. Knowles	C. W. Hoyt R. A. Sheffield (*Non-Member*)
FOLEY, D. F., Sales, W. B. Young Supply Co., Kansas City, Mo.	F. F. Dodds W. A. Russell	Gustav Nottberg C. W. Adams
GAMBLE, C. L., Capt., U. S. Army, Ft. Leavenworth, Kans.	W. A. Russell W. A. Danielson	D. F. Foley J. E. Axeman
HARROWER, W. C., Draftsman, Gar Wood Industries, Detroit, Mich.	W. G. Boales F. J. Feely	R. F. Connell G. D. Winans
HINES, J. C., Air Cond. Engr., R. B. Hayward Co., Chicago, Ill.	R. B. Hayward E. P. Heckel	T. M. Cunningham E. T. Murphy
KNAPP, A. E, Asst. Chief Engr., Kelvinator Corp., Detroit, Mich.	R. F. Connell W. G. Boales	G. D. Winans F. J. Feely
KOFOED, V. B., Dist. Sales Mgr., The Fox Furnace Co., Cleveland, Ohio	F. A. Rodgers R. A. Wilson	W. M. Rowe D. L. Taze

CANDIDATES	REFERENCES	
	Proposers	*Seconders*
KUECHENBERG, W. A., Construction Engr., R. B. Hayward Co., Chicago, Ill.	R. B. Hayward E. P. Heckel	T. M. Cunningham E. T. Murphy
KUNTZ, E. C., Sales, Excelsior Cornice Co., St. Louis, Mo.	J. M. Foster G. B. Rodenheiser	W. L. Dulle R. M. Rosebrough
KURTH, F. J., Tech. Director, Anemostat Corp. of America, New York, N. Y.	T. H. Urdahl A. F. Hinrichsen	A. Rust-Oppenheim (*Non-Member*) Alfred Muller (*Non-Member*)
LEFEBVRE, Design Engr., Warden King, Ltd., Montreal, Que., Can.	T. E. McGrail G. L. Wiggs	C. W. Johnson F. G. Phipps
LEWIS, G. M., Bldg. Engr., Simon J. Murphy Co., Detroit, Mich.	E. H. Clark W. G. Boales	G. D. Winans J. S. Kilner
MABLEY, L. C., Pres., Vitalair, Inc., Toledo, Ohio.	F. L. Myers J. S. Kilner	F. R. Bishop E. B. Root
MATHEWSON, M. E., Engr., A. M. Kinney, Inc., Cincinnati, Ohio.	A. M. Kinney E. B. Royer	G. B. Houliston K. A. Wright
MATOUSEK, A. G., Sales Engr., York Ice Machinery Corp., St. Louis, Mo.	L. J. DuBois E. E. Carlson	G. W. F. Myers H. A. Grossmann
MAURER, F. J., Sales, Crane Co., Pittsburgh, Pa.	P. A. Edwards H. B. Steggall	R. B. Stanger F. H. Hecht
MEDOW, JULES, Design Engr., Ilg Elec. Vtg. Co., Chicago, Ill.	A. G. Sutcliffe L. J. Pitcher	L. D. Stacy H. J. Lagodzinski
MERCER, C. F., Prof. of Physics, Univ. of South Carolina, Columbia, S. C.	R. C. Johnson (*A.S.C.E.*) R. L. Sumwalt (*A.S.C.E.*)	T. F. Ball (*A.I.E.E.*) R. E. Browne (*Non-Member*)
MEYER, JOSEPH, JR., Sales Engr., Edwin Sterner Co., Flint, Mich.	W. J. Schweitzer V. S. Day	D. E. Alton (*A.S.M.E.*) Lawrence Wittman (*A.S.M.E.*)
MUELLER, J. E., Sales Engr., West Penn Power Co., Pittsburgh, Pa.	R. J. J. Tennant W. H. Osterle	F. C. Houghten C. M. Humphreys
OLD, W. H., Asst. Mgr., Glanz & Killian Co., Detroit, Mich.	G. H. Tuttle G. D. Winans	F. J. Feely E. H. Clark
PALMASON, J. H., Assessor, City of Winnipeg, Winnipeg, Man., Can.	C. H. Turland D. G. Michie	Frank Thompson William Glass
REAMER, W. S., JR., Vice Pres., Reamer Industries, Inc., Columbia, S. C.	C. L. Templin I. B. Kagey	L. A. Emerson R. L. Sumwalt (*A.S.C.E.*)
ROSEBROUGH, J. S., Sales, L. J. Mueller Furnace Co., St. Louis, Mo.	C. E. Hartwein G. W. F. Myers	C. R. Davis E. E. Carlson
SCHMIDT, HARRY, Air Cond. Engr., Fedders Mfg. Co., Buffalo, N. Y.	A. E. Seelig H. S. Wheller	E. R. Walker C. L. Meyer
SHELEY, E. D., Pres. & Gen. Mgr., Glanz & Killian Co., Detroit, Mich.	G. D. Winans F. J. Feely	E. H. Clark W. G. Boales
SIMON, ANDREW, Engr., Minneapolis-Honeywell Reg. Co., Cleveland, Ohio.	R. A. Wilson F. A. Rodgers	W. R. Beach L. T. Avery
SINGLETON, J. H., Sales Engr., R. L. Spitzley Htg. Co., Detroit, Mich.	R. L. Spitzley W. F. Arnoldy	H. H. Hill J. R. Bergan
SOGG, ALLEN, Sales Engr., Strong, Carlisle & Hammond Co., Cleveland, Ohio.	R. A. Wilson H. M. Nobis	F. A. Rodgers W. R. Beach
STAFFORD, T. D., Secy. & Mgr., Alexander, Stafford Corp., Grand Rapids, Mich.	S. H. Downs P. O. Wierenga	H. F. Reid F. C. Warren
STELLWAGEN, F. G., Sales, Fitzgibbons Boiler Co., Inc., New York, N. Y.	G. E. Olsen J. A. Darts	H. J. Rose A. T. Miano (*Non-Member*)
VAN NOUHUYS, H. C., Air Cond. Engr., Kelvinator Corp., Detroit, Mich.	W. G. Boales R. F. Connell	F. J. Feely G. D. Winans
WADSWORTH, R. H., Air Cond. Engr., Clarage Fan Co., Kalamazoo, Mich.	W. G. Schlichting C. R. McConner	S. H. Downs H. A. Brinker
WALLACE, D. R., Engr., Young & Bortic Coal Co., Ridgewood, N. J.	Pensyl Mawby O. O. Oaks	E. W. Peters (*Non-Member*) George Israel (*Non-Member*)
WATTS, A. E., Mfr. of Boilers, Silent-Glow Oil Burners, Montreal, Que., Can.	F. G. Phipps G. L. Wiggs	Alexander Wilson Leo Garneau
WEEKS, PAUL, Mgr. Engine Sales Div., Caterpillar Tractor Co., Peoria, Ill.	G. L. Larson D. W. Nelson	B. G. Elliott (*A.S.M.E.*) G. C. Wilson (*A.S.M.E.*)
WEIDELE, E. J., Sales Engr., G. E. Air Cond. Co., Los Angeles, Calif.	Leo Hungerford W. E. Barnum, Jr.	A. H. Simonds H. B. Lauer

Candidates Elected

In past issues of the JOURNAL of the Society the names of the following men were listed as Candidates for Membership. The membership grade of each Candidate has been assigned by the Committee on Admission and Advancement and ballotted upon by the Council. We are now instructed by the Council to post herewith, as required by Art. B-III, Sec. 8, of the By-Laws, the following list of candidates elected:

MEMBERS

ALLCUT, E. A., Prof. Mech. Engrg., University of Toronto, Toronto, Ont., Can.

BARNES, A. R., Chief Engr., U. S. Supply Co., Kansas City, Mo. (*Reinstatement.*)

EVANS, E. C., B. F. Sturtevant Co., Syracuse, N. Y. (*Reinstatement*)

FAIRBANKS, F. L., Prof. Agr. Engrg., Cornell Univ., Ithaca, N. Y.

FAXON, H. C., Appliance Section, The Borneo Co., Ltd., Singapore, S. S.

HANSON, L. P., Design Engr., U. S. Air Cond. Corp., Minneapolis, Minn. (*Advancement*)

HEWETT, J. B., Engr. Mgr., Hudson Air Cond. Corp., Washington, D. C. (*Advancement*)

JONES, J. P., Consulting Engr., John Paul Jones, Cary & Millar, Inc., Cleveland, Ohio.

KAERCHER, C. M. H., Managing Director, Central Bureau for Htg. & Air Cond., Cleveland, Ohio.

KESSLER, M. E., Mgr., Pioneer Elec. Co., Niagara Falls, N. Y.

KNUDSEN, W. R., Mgr. Air Cond. Div., Frigidaire Corp., Chicago, Ill.

MARSHALL, O. D., Mfrs. Repr., Grand Rapids, Mich. (*Reinstatement.*)

MOLONEY, R. R., Asst. Engr. Supt., E. D. Sassoon & Co., Shanghai, China.

MORIARTY, J. M., Owner, Consolidated Htg. & Vtg. Co., Los Angeles, Calif.

REIF, A. F., Pres., Reif-Rexoil, Inc., Buffalo, N. Y.

REIF, C. A., Vice Pres., Reif-Rexoil, Inc., Buffalo, N. Y.

THOM, G. B., Asst. Prof. Mech. Engrg., Swarthmore College, Swarthmore, Pa.

WORTHINGTON, T. H., Br. Mgr., Dom. Radiator & Boiler Co., Ltd., Montreal, Que., Can.

WORTON, WILLIAM, Br. Mgr., C. A. Dunham Co., Ltd., Winnipeg, Man., Can.

ASSOCIATES

BROOKS, H. B., Sales Engr., Smith Distributing Co., Louisville, Ky.

CAMPBELL, F. B., American Radiator Co., New York, N. Y. (*Reinstatement*)

CRAWFORD, A. C., Sales Engr., Potomac Elec. Power Co., Washington, D. C.

CRIBARI, H. E., Sales Engr., American Radiator Co., New York, N. Y.

DETERLING, W. C., Section Head, Industrial Dept., General Electric Co., New York, N. Y.

FORRESTER, C. M., Air Cond. Engr., The Gurney Fdry. Co., Toronto, Ont., Can.

GENDRON, HENRI, Air Cond. Sales Supervisor, Canadian General Electric Co., Montreal, Que., Can.

HOBBIE, E. H., Sales Promotion, Mississippi Glass Co., New York, N. Y.

LA ROCQUE, P. E., Htg. Contractor, Quebec, Que., Can.

MARSTON, A. D., Air Cond. Engr., Kansas City Power & Light Co., Kansas City, Mo.

MARZOLF, F. X., Sales Engr., Minneapolis-Honeywell Reg. Co., Detroit, Mich.

MASON, G. C., Sales Engr., Williamson Heater Co., Cincinnati, Ohio.

MAYER, R. W., Dist. Mgr., Minneapolis-Honeywell Reg. Co., Cincinnati, Ohio.

METCALFE, CURTIS, Engr. (House Htg. Dept.) Detroit City Gas Co., Detroit, Mich.

PEART, A. M., Sales Engr., Minneapolis-Honeywell Reg. Co., Montreal, Que., Can.

PINTO, C. B., Div. Head (Plbg. & Htg.), Montgomery Ward & Co., Jamaica, L. I., N. Y.

SMITH, W. O., Owner, Smith Automatic Heat Service Co., Detroit, Mich.

WESLEY, R. O., Sales Engr., U. S. Radiator Corp., Seattle, Wash.

JUNIORS

BAKER, L. P., Air Cond. Engr., Canadian Gen. Elec. Co., Ltd., Toronto, Ont., Can.

BERGAN, J. R., Sales Engr., Minneapolis-Honeywell Reg. Co., Detroit, Mich.

BENHAM, C. S. K., Sr. Draftsman, Benham & Sons, Ltd., London, W. I., England.

BLACKMORE, J. J., Mfgrs. Repr., Edwardsville, Ill.

CARNAHAN, J. H., Design Engr., Okla. Gas & Elec. Co., Oklahoma City, Okla.

DAUBERT, L. L., Sales Engr., Airtemp Div., Sidles Co., Lincoln, Nebr.

LEWIS, C. A., Draftsman, J. C. Penney Co., New York, N. Y.

MCCAIN, H. K., Sales Engr., G. M. Sales Corp., Atlanta, Ga.

SCHMIDT, KARL, JR., Engr., Detroit City Gas Co., Detroit, Mich.

SCHULZ, E. L., Asst. Commercial Engr., Consolidated Edison Co., New York, N. Y.

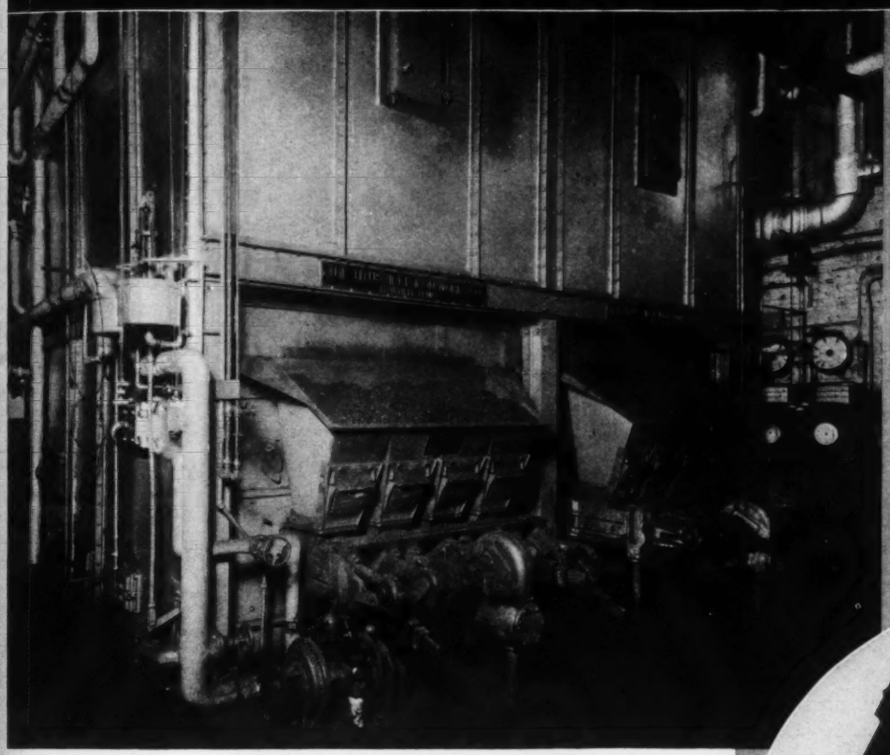
WILSON, H. B., Sales Engr., Brooklyn Union Gas Co., Brooklyn, N. Y.

STUDENTS

ROSENTHAL, EMANUEL, Student Htg. & Vtg. Course, N. Y. Plumbers Specialties Co., New York, N. Y.

SCHLEMMER, B. G., Student, Purdue University, West Lafayette, Ind.

Estimated Savings of $2500



DETROIT MULTIPLE RETORT STOKERS AT THE CATHOLIC UNIVERSITY OF AMERICA — WASHINGTON, D. C.

Detroit Multiple Retort Stokers
The Catholic University of America, Washington, D. C.

● Based on degree days, last heating season, Mr. R. E. Robson, Mechanical Superintendent of The Catholic University of America, Washington, D. C., estimates savings of approximately $2500 by use of Detroit Multiple Retort Stokers with new boilers. ● Mr. Robson has also expressed himself as highly pleased with the overall efficiency and the general operation of the Detroit Stokers. ● Design of Detroit Stokers embodies every feature which can promote economy both in fuel used and in maintenance. ● Deep, square, high capacity retorts, *inclined tuyeres . . . square rams* . . . adjustable moving retort bottoms that provide even fuel distribution . . . correct air distribution by zones . . . rugged, heavy construction—easy adjustment—these features make Detroit Multiple Retort Stokers exceptional in economy and satisfaction. ● Write for Bulletin 178.

DETROIT STOKER COMPANY

Fifth Floor, General Motors Building ● Detroit, Michigan
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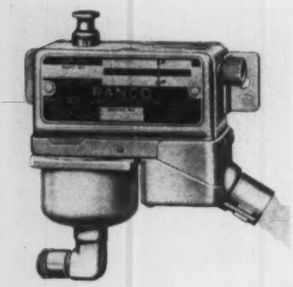
DETROIT STOKERS

Equipment Developments

For your convenience in obtaining more information about any of this equipment, see coupon on page 134. Add the new products and companies listed here to your Directory Section which you received in your January, 1937, HEATING, PIPING AND AIR CONDITIONING and thus keep your records of sources of supply up to date throughout the year . . . Single asterisk (*) indicates equipment not listed in Directory Section; double asterisk (**) equipment and manufacturer not listed.

New Control for Commercial Use

No. 1158**—New stainless steel, corrosion proof thermostat for general commercial use in pressure and temperature control is recommended by the manufacturer for air conditioning service, unit heaters, walk-in coolers, and general commercial applications.



It requires a mounting space of only 4 1/16 x 4 1/4 x 1 7/8 in., and has a rating of 3/4 hp, 110-220 volt a-c; and 1/3 hp, 115 volt d-c. The high rating is made possible because of the wide break which occurs when the overload trips or when the manual switch is operated—and because of heavy contact pressures and liberal silver contact surfaces. Temperature differential ranges from 4 to 20 F. The low pressure differential ranges from 4 to 30 lbs; the high pressure differential of 30 lb is non-adjustable. The low pressure cut-out has a range of 20 to 40 lb, the high pressure 110 to 200 lb. For the temperature cut-out, ranges of —15 to 20; 0 to 35 and 25 to 55 F are available. The range calibration indicator is visible through a window which excludes dust. Both range and differential are adjustable from the outside of the switch.—Ranco, Inc., Columbus, Ohio.

Convector for Hot Water Heating Systems

No. 1159—"Waterflo Convectofin" is a new, specialized, individual room heating convector, offered for service in mechanical circulation hot water heating. It is a copper fin and tube convector, and a companion to the other "Convectofin" heaters.

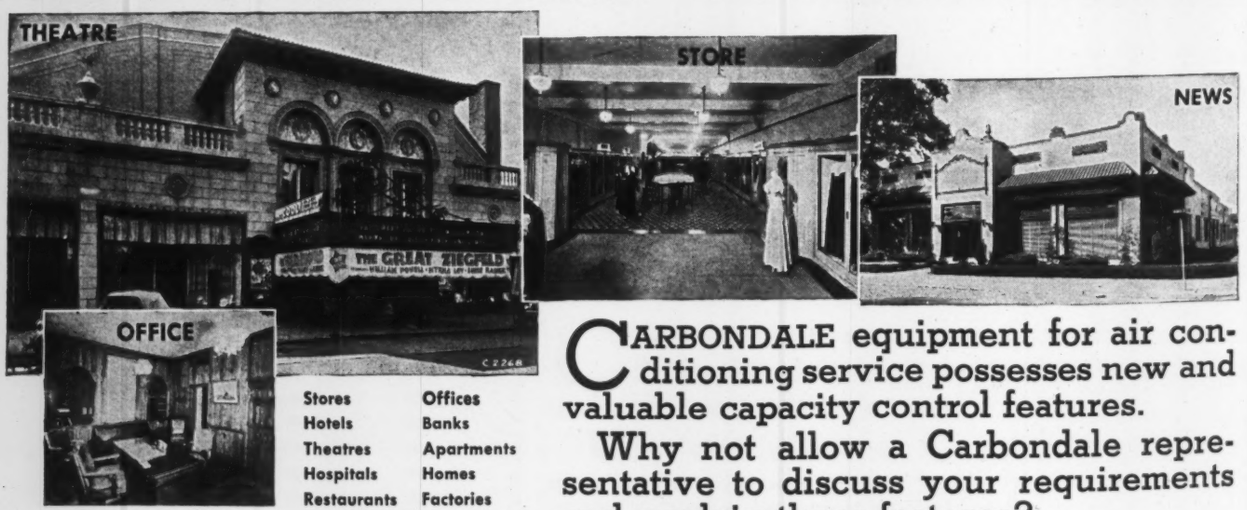
There are two rows of tube banks, the fins are widely spaced in staggered relation, and the medium flows in a series circuit. The small ratio of exposed areas, large water contact with the live heating surfaces, and free air travel, give an arrangement which assures the needed high heat transfer with hot water, according to the maker.

The tubes of the unit's heating element are expanded into two cast headers, and supported on legs. Flow and return connections are brought out at the same end; no bushings are used; the combination header has considerable volume for circulation as well as air; and two extra tappings are provided so that either one or both sides of the circuit may be vented.—Commodore Heaters Corp., 11 W. 42nd St, New York, N. Y.

Small Self-Cleaning Air Filter

No. 1160.—The new "Unimatic" self cleaning air filter has been developed especially for smaller than average air volumes where hand crank or push-button control is practical. Actually, it is a self cleaning unit filter, since the filter curtain is made up of a number of standard units, the maker states. There are

More typical examples of
CARBONDALE AIR CONDITIONING



Stores Offices
Hotels Banks
Theatres Apartments
Hospitals Homes
Restaurants Factories
Public Buildings

CARBONDALE equipment for air conditioning service possesses new and valuable capacity control features.

Why not allow a Carbondale representative to discuss your requirements and explain these features?

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ATLANTA BOSTON BUFFALO CHICAGO CINCINNATI CLEVELAND DALLAS DENVER DETROIT EL PASO HOUSTON KANSAS CITY

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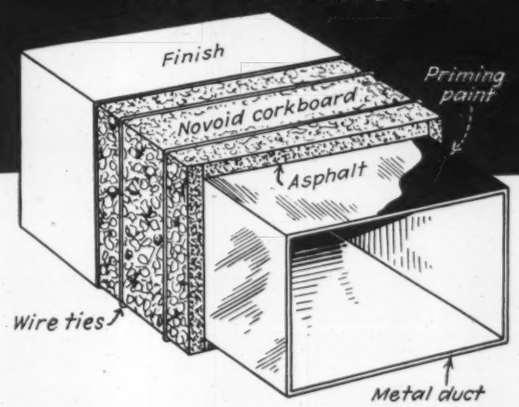
Representatives in Principal Cities of Foreign Countries

LOS ANGELES NEW ORLEANS NEW YORK PHILADELPHIA PITTSBURGH ST. LOUIS ST. PAUL SAN FRANCISCO SEATTLE TULSA WASHINGTON

FOR INSULATING AIR-CONDITIONING DUCTS AND PIPING...



YOU CAN'T IMPROVE ON CORK

NATURE'S best insulator is the bark of the cork tree. And from this efficient material Novoid Cork Insulation is fabricated into three forms—Corkboard, Corkduc and Cork Pipe Covering.

Because of its natural physical properties, Novoid forms a positive barrier to the passage of heat, and permanently prevents condensation. In Corkboard and Corkduc forms, Novoid is ideal for insulating both square and rectangular ducts and many other parts of air conditioning and ventilating systems. And in the form of Cork Covering, Novoid gives equally dependable protection to cold water pipe lines in all types of air conditioning work.

It will pay you to use nature's best means of insulating. With Novoid you can help assure more accurate temperature control and lower operating costs on every installation. For full particulars, mail the coupon, or write Cork Import Corporation, 330 West 42d Street, New York City. Branch offices: Chicago, 400 W. Madison St.; Boston, 27 Haymarket Square; Philadelphia, 1524 Chestnut St.

NOVOID CORKBOARD

MAIL COUPON FOR COMPLETE DETAILS

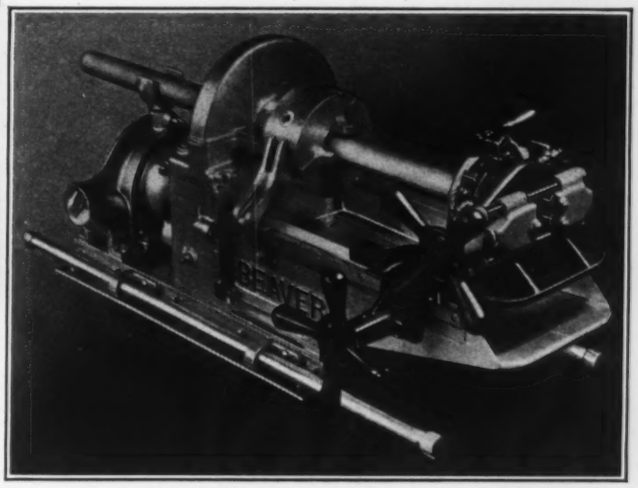
Cork Import Corporation
330 West 42d Street, New York City

Please send me information on Novoid Corkboard, Corkduc and Cork Pipe Covering for air conditioning systems.

Name .....

Street .....

City and State .....



Can You Spare 3c a Day?

Figure it out for yourself! The BEAVER Model-A SPECIAL costs you $295.00. This amount invested at 3%—a liberal return nowadays—would bring you an income of $8.85 a year—or less than three cents a day. That is what it actually costs you to own a BEAVER Model-A SPECIAL Pipe Machine. Note these features!

1. IT IS A FULL RANGE MACHINE—⅛ to 2-inch—not merely ¼ to 2-inch. It cuts, threads, reams and chamfers all sizes up to 2-inch.
2. LARGER SIZES—from 2½ to 12-inch—may be cut and threaded with geared tools and drive shaft.
3. IT CUTS AND THREADS SOLID ROUND BARS for making staybolts, pipe hangers, etc. This is an important advantage of the wheel-cutoff.
4. IT IS RIGHT-HANDED—like a lathe or any other standard machine tool.
5. ALL CONTROLS ARE IN FRONT—right at your finger tips. Quick-opening adjustable die heads—no backing off.
6. STANDARD BASE-MOUNTING UNIVERSAL MOTOR connected by a flexible coupling. Operates from AC or DC current 25 to 60 cycle. 110 or 220 volt optional. Motor and switch heavily guarded. Reverses at switch.
7. STANDARD ALL-STEEL CHUCK with chuck wrench ejector. An important safety feature.
8. ALL GEAR DRIVE—no belts.
9. RACK AND PINION FEED—inverted type. Cannot clog from chips.
10. OUTBOARD PIPE SUPPORT—stops the whip of long lengths of pipe and eliminates bad threads caused by pipe whip.
11. OIL PUMP ACCESSIBLY LOCATED on the outside. Reversible. Oil lines concealed—can't get knocked off.
12. SPEED. CUTS 2-INCH PIPE IN TEN SECONDS. Threads it in thirty seconds. Reams in three seconds.

The price of one postage stamp a day—that is what it actually costs you for your investment in the Model-A BEAVER SPECIAL ⅛ to 2-inch portable electric pipe machine.

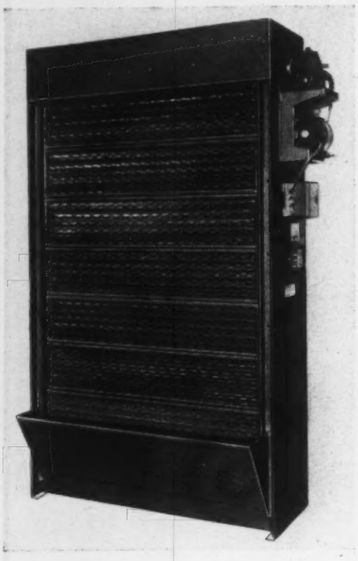
Sold by leading jobbers everywhere. Catalog upon request.

BEAVER PIPE TOOLS

237 Keeney Ave., Warren, Ohio

two additional units to those required to make up the curtain; one submerged in the reservoir being cleaned, and the other draining at the back of the filter.

The cycle of operation consists of raising the clean, drained unit to the top of the curtain and lifting the submerged unit to the draining position which permits the bottom unit in the curtain to slip down into the cleaning position. This change is made once a week, once a day, or as frequently as required by the size of the filter and the dust load, to maintain uniform operating conditions.

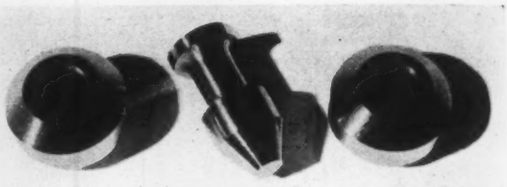


Available in capacities from 1,000 to 30,000 cfm.—American Air Filter Co., Inc., 107 Central Ave., Louisville, Ky.

High Pressure Refrigeration Valves

No. 1161—Two 13 mm valve seats and a valve plug of a nonferrous cobalt-chromium-tungsten alloy now in use in the high pressure end of the refrigeration unit at a large chemical plant are illustrated.

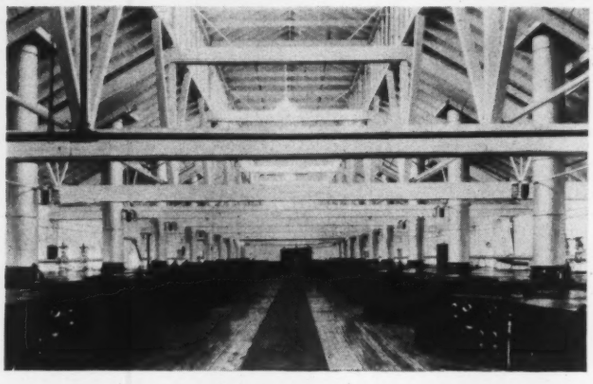
Valve seating surfaces of this material have been found to last six to ten times as long as ordinary seating surfaces under severe



service conditions, according to the Haynes Stellite Co., Kokomo, Ind., who cast the seats and plug.

Stainless Clad Steel Stacks and Ducts

No. 1162—Frequent replacements of stacks, ducts and large diameter piping subject to corrosive attack have been eliminated in many industrial plants by adopting stainless clad steel construction. A fabricating procedure has been developed for stack, duct and piping construction that assures complete stainless steel corrosion protection on the interior surface, combined with simplicity of fabrication, it is stated.



For

DUCT WORK

Duct work is one of the many sheet metal jobs where Stanley Unishears make slow, tedious hand cutting obsolete IN THE SHOP OR ON THE JOB.

See for yourself how it zips through sheet metal as fast as you feed. Unishears follow any straight or curved line accurately, leave smooth finished edges—no distortion of metal. Ask your Stanley distributor for a demonstration or write for full information. Stanley Electric Tool Division, The Stanley Works, 102 Elm Street, New Britain, Conn.

No. 16 UNISHEAR

Capacity, 16 gauge galvanized iron, other materials in proportion. A good size for all-around work. Other Unishears, both portable and stationary, are available. Capacities from 18 gauge galvanized iron up to ¼" boiler plate.

STANLEY UNISHEARS THE ELECTRICALLY DRIVEN HAND SHEARS

Portrait of a Man About to change to SUPER-SILVERTOP

• This man is fed up on the old complicated method of steam trap piping and is about to change to Super-Silvertops and the new simplified way of using this modern trap either as elbow or straight-in-line.

Plant owners and managers naturally prefer the neat, attractive appearance of Super-Silvertop piping. It is so clean cut, so sensible and saves so much installation time—as much as 60 minutes per trap. Then too, Super-Silvertops do not leak steam, hence they work on vacuum as well as on pressure. Traps that are not recommended for use on vacuum definitely leak steam.

Super-Silvertops are easy to inspect or clean—it is not necessary to remove the trap from the line. In addition, Super-Silvertops have much more capacity, averaging 76% more than all other traps. Write today for complete information and prices.

THE V. D. ANDERSON CO.
1949 West 96th St. • Cleveland, Ohio

THE *Only* COMPLETE STEAM TRAP

NOW! *For An Easier, Better Way To Cover Metal Air Ducts . . .*

Air Duct of The Upjohn Company, Kalamazoo, Michigan, completely covered with Celotex.

• In all parts of the world, engineers are specifying Celotex for covering metal air ducts—because they find it keeps air-conditioning apparatus functioning more efficiently—and assures low operating costs.

• Celotex Insulating Board has a thermal conductivity of only 0.33 Btu. per inch thickness. The big, light, rigid boards go up fast—cut easily—fit tightly in place. And once up—they *stay put!*

• If vapor condensation is one of your problems, specify Celotex VLTI—the vaporproofed low temperature insulation blocks that are *completely sealed* against vapor penetration at the factory by a special wrapping and coating.

• Celotex Insulating Board and VLTI are protected against termites and dry rot by the patented Ferox Process. Write us today for all the facts about these widely used insulations.

CELOTEX
BRAND——INSULATING CANE BOARD
Reg. U. S. Pat. Off.
World's Largest Manufacturer of Structural Insulation

TWO Big Advantages

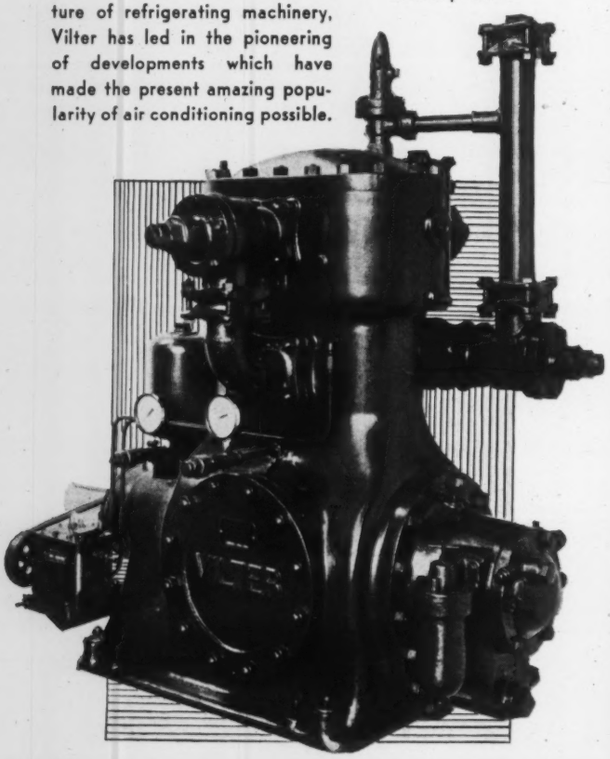
Now Available for the FIRST Time . . .

1 The Vilter "Freon 12" Compressor brings to the air conditioning field a new and revolutionary standard of performance for the modern low-pressure refrigerant compressors. By the application of a fundamental principle Vilter Engineers have produced a shaft seal which eliminates leakage with uncanny effectiveness and makes for high efficiency at minimum cost.

2 Eliminating ordinary construction features which require power, and refining other mechanical factors enabled Vilter Engineers to produce a New Freon compressor that is amazing Engineers with its unusually low relative horsepower requirement.

Throughout an experience of over fifty years in the manufacture of refrigerating machinery, Vilter has led in the pioneering of developments which have made the present amazing popularity of air conditioning possible.

Vilter "Freon - 12" Compressor



THE VILTER MANUFACTURING COMPANY
"SINCE 1867"
2148 South First Street
MILWAUKEE, WISCONSIN
REPRESENTATIVES IN PRINCIPAL CITIES

Stainless clad steel, which has a 20 per cent layer of 18 chrome, 8 nickel steel welded to a base of mild steel is used in thicknesses of 16 ga or heavier. In preparing the sheets, all edges are flanged outward. When formed or rolled into a section of piping there is, therefore, a peripheral or circumferential flange at each end of the section and a longitudinal flanged seam, the length of the section. Due to the ease of forming clad steel, the straight flanges may be formed over a bar, or formed on an apron forming or press brake. In the case of round piping the flange may be formed over a ring jig, or other satisfactory method.

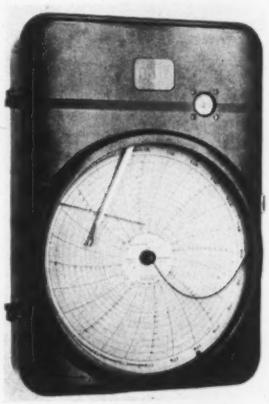
All joints are welded on the projecting flanged edges, and welding may be done by either metallic arc or oxy-acetylene process; stainless steel welding rod must be used to insure a complete stainless steel interior of the duct. Welding speeds of 40 to 60 linear feet per hour may be maintained.

The illustration shows stacks carrying fumes away from soap kettles.

It is the usual practice to make up sections of the stacks or ducts in the sheet metal shop and make final welds in position in the field. If welding in the field is impracticable, sections may be connected by the use of van stone rings, or riveted or bolted together, using gaskets between sections.—Ingersoll Steel & Disc Div., Borg-Warner Corp., 310 S. Michigan Ave., Chicago, Ill.

Electric Flow Meters Operate on Telemetering Principle

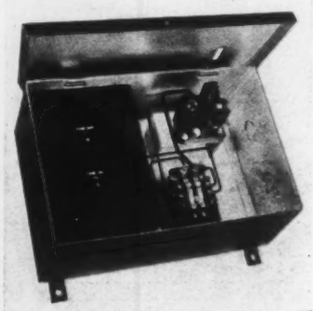
No. 1163—New electric flow meters for steam, liquids, and gases operate on the "Metameter" principle of telemetering, which has been used for several years in instruments to transmit readings of pressure, liquid level, temperature, and motion from the point of measurement to a distant point where they are recorded or indicated on a dial.



These meters can be furnished for recording, integrating, and indicating flow. The readings are transmitted over a simple two-wire circuit, telephone circuits included, which does not enter into the calibration of the instruments. All electrical contacts are enclosed in glass. A standard meter body is employed to measure the differential across an orifice. High accuracy is obtained at all points on the scale, says the maker.

Both transmitter and receiver are equipped with moisture, fume, and dust proof aluminum alloy cases. Conduit openings are provided so that the instrument may be used with modern wiring systems.—Bristol Co., Platts Bridge, Waterbury, Conn.

Timer for Stoker Control



No. 1164—New "Klixon" timer for automatic stokers has a number of features. With it, it is possible to have more flexible control for maintaining fires, according to the maker. The timer can be set to turn the heat on at intervals ranging from ½ to one hour, and it can also be set to keep the heat on any length of time ranging from

THE DEPENDABLE CHOICE OF ENGINEERS, ARCHITECTS AND HEATING CONTRACTORS . . .

AEROFIN
Heat Exchange Surface
PROVED PERFORMANCE

MORE Aerofin heating and cooling surface is used than any other type because Aerofin consistently meets the most exacting demands of engineers, architects and heating contractors who cannot afford to take chances on performance.

They know that Aerofin performance has been *proved* in thousands of installations. They know that they can specify it with confidence, secure in the knowledge that it will live up to its reputation as the most advanced type of heat-exchange surface on the market.

There are many reasons for Aerofin's superiority. For example—Aerofin's crown orifice in heating units prevents scale clogging. Aerofin's centrifugal header in direct expansion units assures rapid and even distribution of refrigerant through the coils with a minimum number of expansion valves. Aerofin's removable header on water units permits easy cleaning of tube interiors.

These are exclusive features in Aerofin which have earned and held the confidence that it enjoys.

Why not start 1937 by specifying Aerofin on your next job? A complete line of equipment for heating and cooling is at your service. Our home office in Newark or any of our branch offices will gladly send descriptive literature or render prompt, effective technical cooperation.

AEROFIN is sold only by Manufacturers of Nationally Advertised Fan System Apparatus. — List upon Request

AEROFIN CORPORATION
850 Frelinghuysen Avenue
Newark, N.J.
Chicago Detroit New York Philadelphia

Line your Ducts with this
SAFE
SOUND ABSORBENT

Burgess Acousti-Pad is a metal-faced acoustic lining for ventilating ducts. The perforated facing permits duct noises to seep into the underlying sound-absorbing blanket. And it also prevents the sound-absorbing material from blowing into the air stream.

Most important, from a safety standpoint, is the restrictive action of the perforated facing to flame travel within the duct. Like the screen of a miner's lamp, the Burgess perforated facing restricts any flame from traveling freely along the lined interior of the duct.

Send for new bulletins describing the exceptional advantages of this remarkable lining. Every modern air-conditioning job needs Burgess Acousti-Pad.

Also send for Bulletin 126, describing the Burgess Acoustic Communication Booth for noisy locations.

Burgess Battery Co., Acoustic Div.
111 W. Monroe St., Dept. H
Chicago, Ill.

Licensed under C. F. Burgess Laboratories, Inc., Patents

OUR CATALOG IS FILED IN SWEET'S

BURGESS ACOUSTI-PAD

MFRS. OF BURGESS ACOUSTI-PAD AND ACOUSTI-VENT, AUTOMOTIVE MUFFLERS, SILENCERS AND AIR CLEANERS

two to seven minutes. These settings are entirely independent of each other.

Another feature is a device for preventing the timer from going on if the thermostat has been calling for heat and the fire has been built up. The timer remains idle when the thermostat is functioning. Furthermore, the length of time that the timer remains idle after the thermostat shuts off is automatically regulated in proportion to the length of time the thermostat has been calling for heat. If the thermostat has been calling for heat for a long period of time and the fire is built up to a high temperature the timer will remain idle longer than its set time to allow the fire sufficient time to cool down. If, on the other hand, the thermostat has been on for only a short time, the timer's idle period is automatically shortened in order to eliminate all chances of the fire's going out.

Completely electric, this timer has no clock mechanism or rotating part.—Spencer Thermostat Co., 34 Forest St., Attleboro, Mass.

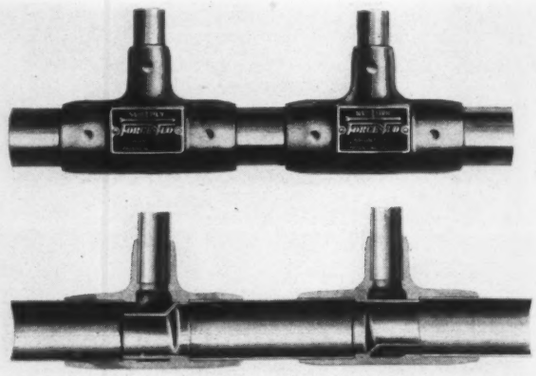
Universal Pillow Block

No. 1165—Because it often is impossible to know in advance of a machine installation how the pillow blocks will have to be mounted, a universal type double reservoir oil return pillow block that can be mounted in any position according to the requirements of each individual installation has been developed. It is necessary only to select the mounting position needed, unscrew the oil cup, turn the ball to this position and reinsert the oil cup vertically.

The pillow block has two large reservoirs in the spherical ball. A supply of oil is placed in the upper one which feeds the shaft as needed through graphite feed plugs and graphite pressure packed channels. Oil recovery grooves divert unconsumed oil into the lower wool packed reservoir. This oil is again fed to the shaft and bearing through lower graphite feed plugs. The bearing is self-aligning and is precision bored to close tolerances. —Randall Graphite Products Corp., 609 W. Lake St., Chicago, Ill.

Copper Shunt Tee for Single Main Hot Water Heating Systems

No. 1166*—New copper streamline shunt tee for "Force-flo" single main hot water heating systems rounds out a complete line of steel and copper shunt tees all of same basic principle of design.



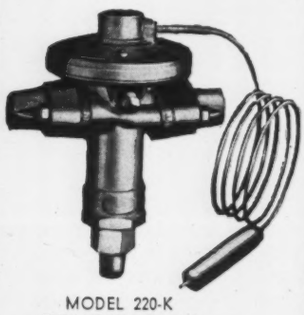
This new tee will also be made under the patents of the Mueller Brass Co. Aside from its patented interior construction the tee will be similar to the standard Mueller "Streamline" tee.

It is claimed by the manufacturers that this new shunt tee will reduce cost of installation and operation on copper heating work, and will improve appearance by reduction of pipe sizes and number of mains. —Stevens-Root Co., 51 E. Grand Ave., Chicago, Ill.

Built to Serve Without Service Trouble

Controls have successfully licked the common mistakes which are responsible for the great majority of service troubles. Mechanical failure to function under varying conditions is a thing of the past wherever Thermostatic Expansion Valves and Refrigerant Controls are used.

Relentless laboratory testing is responsible for the absolute accuracy and safety with which Controls function in daily use.



MODEL 220-K EXPANSION VALVE

Controls are the result of great practical experience in designing and creating controls for difficult situations and they offer basic features and advantages not available in other like units.

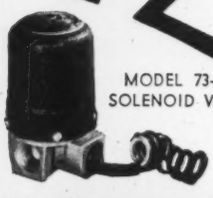
Thermostatic Expansion Valves may be installed in any position, or in any temperature even though higher or lower than the bulb.

AUTOMATIC PRODUCTS COMPANY
2460 N. 32nd Street
MILWAUKEE WISCONSIN

PROGRESSIVE JOBBERS EVERYWHERE STOCK CONTROLS

MODEL 78 SOLENOID VALVE

MODEL 70-N SOLENOID VALVE



MODEL 73-R SOLENOID VALVE

REFRIGERANT CONTROL VALVES

Save Money on Your Piping and Gain These Advantages with WELDOLETS·THREDOLETS

Eliminate all preliminary layouts of main pipe and branch. No templets are necessary. All cutting, threading, forming and fitting of main pipe eliminated. Permit making any type of outlet—tee, side-outlet, cross, etc. All joints leak-proof and full pipe strength. Heavy external rib compensates for loss of strength in main pipe when hole is cut. Funnel-shaped outlets of WeldOlets and ThredOlets eliminate "dead spots" providing free flow conditions. Turbulence and friction reduced to a minimum. Make neater, more workmanlike joints. Adapted to new construction or for maintenance. Suitable for use in high pressure lines or where high temperatures are used. Available with outlet sizes of ½" to 12" for all standard pipe sizes. Supplied in Wrought Iron, Toncan Iron, Brass, Bronze, Copper, Nickel, Monel, Everdur etc. to meet your specific needs. Installed by Oxy-Acetylene or Electric-Arc welding.

"WeldOlets" and "ThredOlets" are fully covered by U. S. and foreign patents and are trade marks registered in the United States Patent Office.

Write for Bulletin WT21 giving full details.

Bonney Forge and Tool Works

Cedar & Meadow Sts., Allentown, Pa.

Stocked by Leading Distributors

WELDOLETS·THREDOLETS

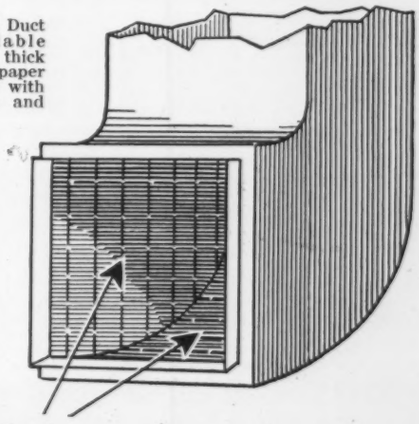
Ozite makes A *Gale* OF AIR···

AS QUIET AS A BREEZE

Air may rush through your air ducts at terrific speed, but it will never roar or cause rumbling vibrations, if entrances, exits, and other strategic points are lined with Ozite Hair Felt Duct Lining. Made entirely of hair, Ozite absorbs not only the sound caused by moving air, but also the hum of motors and the whir of fans and blowers. Ozite Duct lining is amazingly easy to apply. It will stay on the job and prove a lasting tribute to your good judgment. Write today for samples and details!

AMERICAN HAIR & FELT COMPANY
Merchandise Mart Chicago, Illinois

Ozite Hair Felt Duct Lining is available ½" thick or 1" thick in bats with paper cover or felted with burlap backing and latex facing.

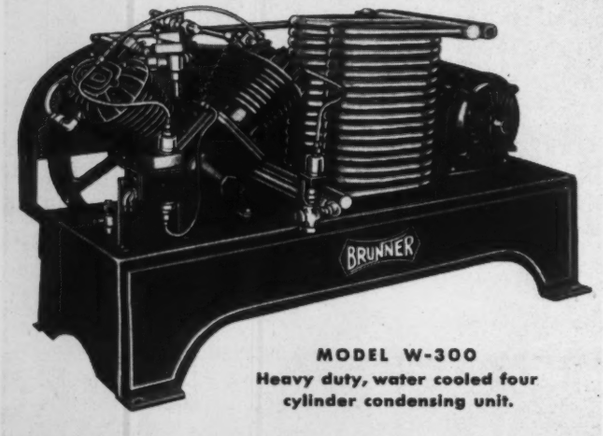


Ozite
HAIR FELT
AIR DUCT LINING

Be Sure!
THE CONDENSING UNIT MATCHES!

Be certain the Condensing Unit you specify in your air conditioning installation matches the quality of your other equipment... Brunner Condensing Units have a universal reputation for dependability and embody structural improvements which reflect the newest advances in air conditioning... A wide range of models provide the exact capacity for all applications up to 15 tons of refrigeration. Catalog upon request. Brunner Manufacturing Co., Utica, N.Y., U. S. A.

BRUNNER CONSULTING SERVICE
Brunner engineers are ready to cooperate with you in the selection of the correct condensing unit... No cost or obligation.



MODEL W-300
Heavy duty, water cooled four cylinder condensing unit.

BRUNNER
for Greater Dependability!

Utility of Rust Proofing Process Increased

No. 1167—Until recently, most of the chemical rust proofing processes in commercial use were formulated to react on iron and steel only. However, a new process that produces a corrosion inhibiting coating on galvanized, zinc alloy and cadmium surfaces, as well as on iron and steel, has been announced. In addition to being corrosion resistant, the coating is highly adherent, being integral with the metal itself, and having slight porosity; it is said by the manufacturer to form an ideal base for any type of paint finish.

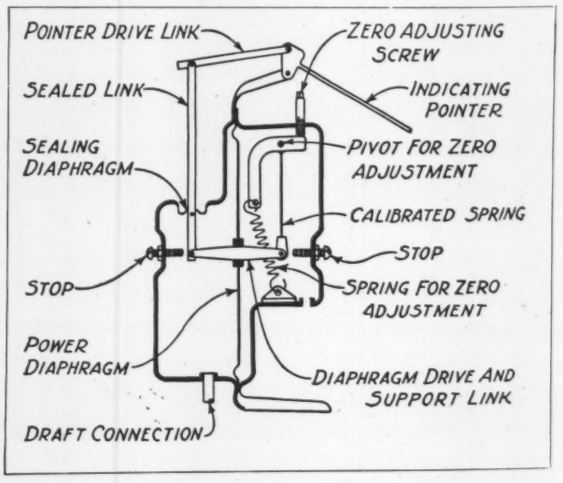
The process is called "Dip-Spra Bonderizing," and it is stated to combine the coating efficiency of the prior "Spra-Bonderizing" process with the lower equipment costs and conveniences of an immersion process, as well as widening the utility of the process to include certain non-ferrous metals.

The equipment requirements are comparatively simple, consisting only of a steam heated processing tank of suitable size, in which a spray pipe is placed above the solution level. This spray pipe is plain stainless steel, drilled with a series of ⅛ in. holes from 2 to 4 in. apart, through which the solution is circulated by a small pump, placed at one end of the tank. Large or deep tanks are fitted with a spray pipe on each side.—Parker Rust-Proof Co., 2177 E. Milwaukee Ave., Detroit, Mich.

Multi-Pointer Gage for Boiler

No. 1168—A new diaphragm operated multi-pointer gage has been developed for boiler room service. Its feature is the diaphragm material, which is resistant to oil, acid, caustic and heat, says the manufacturer, who states that it possesses exceptional flexibility and strength.

The diaphragm operated unit consists essentially of a flat calibrated spring, a sealed link, and a power diaphragm the weight of which is carried on a second link pivoted at one end on the calibrated spring and at the other end on the sealed link. Draft is applied on the left side of the diaphragm, which causes movement of the system to the left. This movement is opposed by the flat calibrated spring. The motion is transmitted by the sealed link to the outside of the diaphragm unit where a drive link carries the motion to the indicating pointer.



For indication of pressure the connection is made on the opposite side of the diaphragm, and for indication of differential pressure the connections are made to both sides of the diaphragm.

Exceptional sensitivity and accuracy are said to result from the construction by which the force of draft, pressure or differential on the diaphragm is transmitted directly to the opposing calibrated spring through one pivot only. This construction eliminates mechanical friction and attendant discrepancies between up and down readings.—Bailey Meter Co., 1050 Ivanhoe Rd., Cleveland, Ohio.

BALDOR BUILDS *Better Motors*

Where you find AIR CONDITIONING

you find BALDOR *Motors*

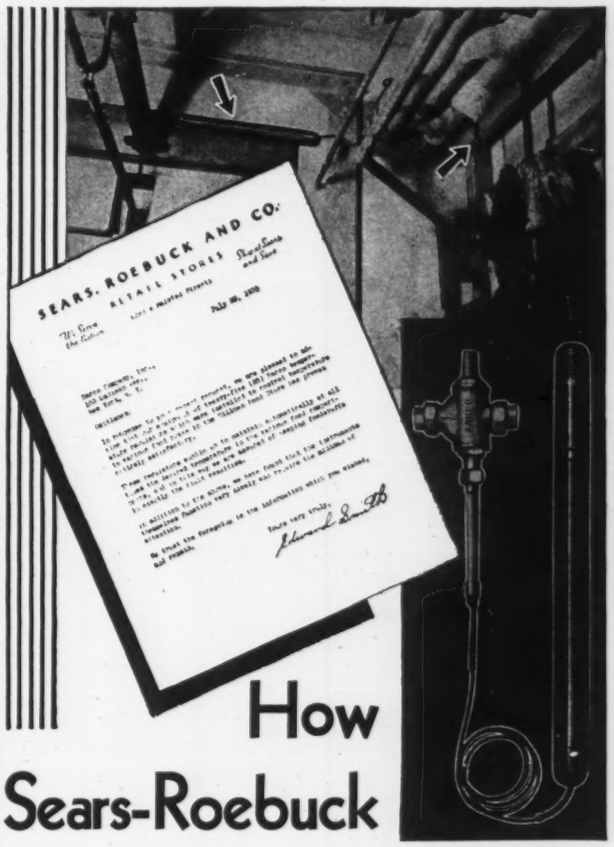
AIR-CONDITIONED PULLMANS ARE EQUIPPED WITH BALDOR MOTORS

When the manufacturers of Railway Air Conditioning equipment needed a sturdy dependable motor to withstand extra hard service, under all weather conditions, they chose Baldor Motors.

Baldor has specialized in motors for automatic heating and air conditioning service since the industry began and has pioneered and developed many important advances in motor design and engineering.

BALDOR ELECTRIC COMPANY
4300 DUNCAN AVE. - - - - - - - - ST. LOUIS, MO.
Sales and Service Offices in Principal Cities

BALDOR
A BETTER MOTOR



How Sears-Roebuck Keep Foodstuffs Right

To prevent spoilage of foodstuffs at the Hillman Food Store of Sears-Roebuck & Co., they installed 25 Sarco Temperature Regulators to control the flow of brine through the coils in food storage boxes and display counters.

You will note their letter states, "These Regulators enable us to maintain automatically, at all times, the desired temperature . . . and in this way we are assured of keeping foodstuffs in exactly the right condition . . . they have proven entirely satisfactory."

Operated by liquid expansion, Sarco Temperature Regulators have the same power at low temperatures as others develop only on heating service.

When set for any temperature, they automatically maintain it without attention. No compressed air, electricity or water pressure is needed to operate.

Write for information regarding 30-day free trial and Catalog 0-54.

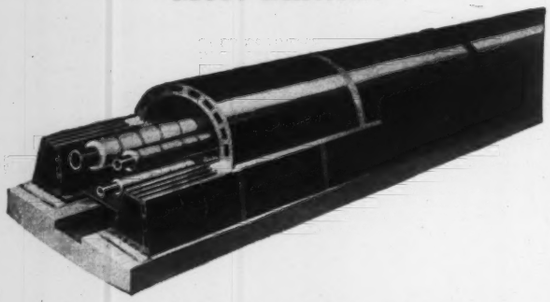
SARCO COMPANY, INC.
183 Madison Ave., New York, N. Y.
Branches in Principal Cities
Sarco Canada Limited, Federal Bldg., Toronto, Ont., Canada

SARCO TEMPERATURE REGULATOR

THERM-O-TILE

The Conduit for Underground Steam Lines

Simplest
Strongest
Most Efficient



Complete data and estimates on request.

Sold and Installed by Johns-Manville Construction Units in all Principal Cities.

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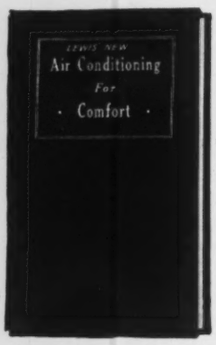

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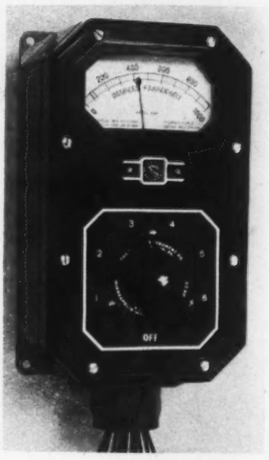
Pyrometer for Diesel Engine Service



No. 1169—A pyrometer designed especially for diesel engine service is available in three temperature ranges, 0-1000 F, 0-1200 F and 0-1600 F and with the following combinations of switch points: 4, 6, 8, 12, 16 or 24. The 0-1000 F range instrument is also available with "cold," "normal" and "danger" operating zones plainly indicated on the scale.

The measuring system is rugged and is capable of close accuracy under the severest service, according to the maker. It is provided with a special neutralizer having a negative temperature coefficient to permit the use of heavy springs in the system while still maintaining a low overall temperature coefficient.

Each pyrometer is calibrated within 1 per cent of full range in the normal operating zone and within 2 per cent outside that zone.—Brown Instrument Co., Div. of Minneapolis-Honeywell Regulator Co., 4534 Wayne Ave., Philadelphia, Pa.

Improved Self-Operating Temperature Controllers

No. 1170.—Improvements in 30 year old line of self-operating temperature controllers include a new design of flexible seamless metal bellows and minor refinements of design, material and workmanship.

The unit is suitable for industrial applications where the close control obtainable with auxiliary power is not necessary or where the steam pressure available is less than that required for opening steam-operated controllers. Temperature ranges are approximately 75 F between the limits of 30 and 450 F. The valves are semi-balanced, in size from ½ to 2 in.—C. J. Tagliabue Mfg. Co., 540 Park Ave., Brooklyn, N. Y.

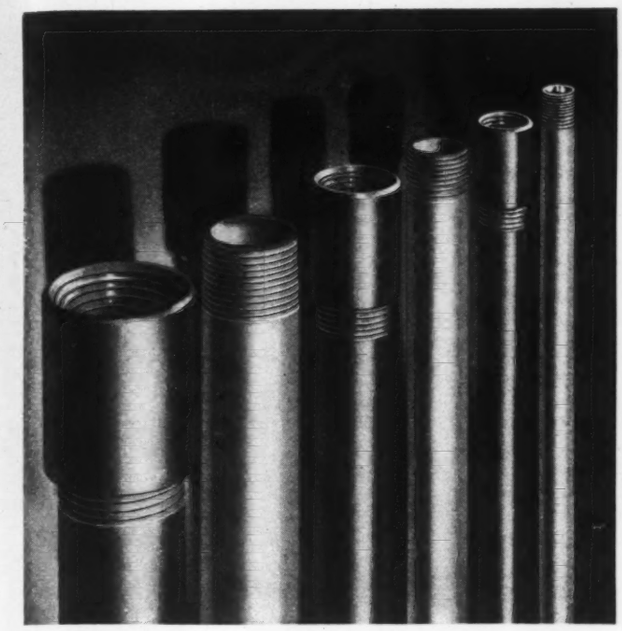
New Capacitors Increase Efficiency of Power Distribution

No. 1171.—A new type of weatherproof, steel clad, hermetically sealed 15 kva capacitor unit suitable for pole mounting on distribution circuits, has been announced. These units contain an internal discharge device and are provided with means of mounting on brackets to cross arms or direct to poles, or in groups of four on single angle iron racks, making possible inexpensive installations up to 180 kva on one pair of cross arms.

The increasing use of air conditioning and refrigeration and other motor-operated devices is emphasizing the need for eliminating reactive current from distribution circuits, particularly circuits of the 4 kv class. Reactive current in these circuits causes a voltage drop much in excess of the drop resulting from the power current. The use of these new shunt capacitors on distribution circuits will greatly increase the power handling capacity and the over-all efficiency of distribution, according to the manufacturer.—Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

Automatic Coal Fired Air Heater for Industrial Use

No. 1172**—New automatic coal fired industrial air heater has been designed for space heating service or for use in connection with ovens. The stoker is of the underfeed worm type. One motor, controlled by a thermostat, drives both the fan for



LET'S THROW SOME LIGHT ON THIS MATTER OF *Pipe*

Pipe is probably the most important item in a plumbing system—for without it, how could you have a system—how could you convey water, steam and gas? • Yet pipe probably receives the least thought of any part of the system. To many people, it's just pipe—or steel pipe. • But there is a difference—take Fretz-Moon Pipe, for instance. It is made of clean, coiled skelp of high quality, passed through a special heating furnace which heats it to a definite temperature and then immediately passed through specially designed rolls which form and weld it into a strong, sound tube uniform in every respect, highly ductile and free from hard spots that cause trouble in bending, cutting and threading. Another feature of utmost importance is the fact that during passage through the furnace, never once does it come in contact with the furnace bottom. Thus, it is as clean inside as outside. All mill scale is removed. • If you would use quality pipe at no increase in cost, consider Fretz-Moon.... Ask your jobber or write us.

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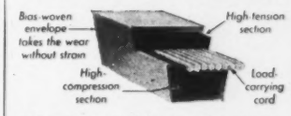

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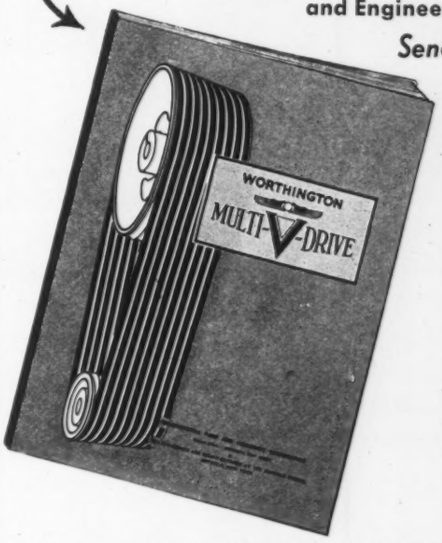

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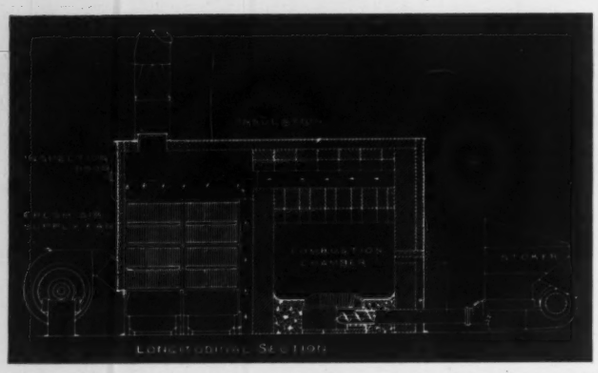


supplying air for combustion and the worm feed. The combustion chamber is encased in heavy steel plate. Upper part of the walls and the top arch are insulated; the bottom portion of the walls up to the top of the fuel bed line is air cooled.

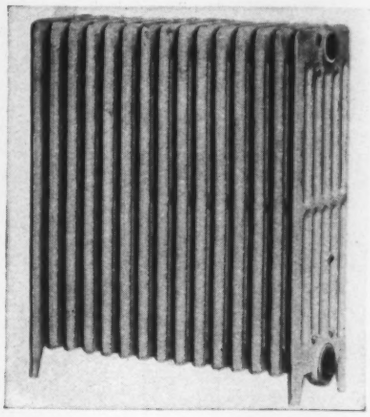
Automatic bypass damper in roof of gas chamber above tubes is normally closed when heater is in operation. However, if for any reason the fan handling the gases or the supply fan handling air through the interchanger tubes stops, damper automatically opens and the gases pass up the stack to prevent damage to the tubes. The heat interchanger is built of rectangular steel tubes, and the air to be heated flows counter to the gases.

Among the features stressed by the manufacturer are low first cost, operating cost, and maintenance cost, and safety and convenience. The unit forms the basis for an air conditioning system, it is stated, as humidifying, dehumidifying, cooling, washing, and filtering equipment can be added, the blower unit being an integral member.

May discharge heated air direct into space or through ducts.—James Campbell Smith, Inc., 16374 Euclid Ave., Cleveland, Ohio.

Cast Iron Radiator for Modernization Work

No. 1173.—A new six tube, cast iron radiator has been designed to be especially adaptable to modernization work, where the use of concealed convectors might mean major structural changes, and for new work when the cost will not permit completely concealed radiators and yet space and decorative requirements demand inconspicuous radiators.



Available in three heights of 9, 25 and 32 in., the new radiator is 7⅞ in. wide with 1½ in. centers. Tappings are 1¼ in. at the top and 1½ in. at the bottom, and connections for both steam and water are 1¼ in. malleable nipples at top and bottom.

The square feet of radiation per section is 2.2, 2.9 and 3.8, varying with the height. — American Radiator Co., 40 W. 40th St., New York, N. Y.

Grinder for Threading Dies and Chasers

No. 1174—A new grinder for threading dies and chasers of all kinds is equipped with a special fixture and wheel for each type of chaser to be ground, and is said to be simple to set up and operate. Micrometer adjustments make it possible to obtain a

REX-WELD "Super-Service"
VIBRATION ABSORBERS
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● Here's the ideal solution to the compressor noise problem! Installed in the suction and discharge lines, these Rex-Weld Flexible Metal Tubing Units effectively dampen the vibration and put an end to the annoying hammering—surely, safely and economically . . . Produced by an exclusive patented process which forms the flexible tubing corrugations without weakening the special, non-porous, non-crystallizing bronze alloy. Supplied complete with capped ends ready for sweating onto standard water tubing. Write for Bulletin RW-4 and Data Sheet. Send us your specifications for prices.
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INSPECT your Steam Conduit BEFORE it goes into the ground! That will mean a lot less trouble. You don't need a magnifying glass and a brace of bloodhounds to show you the EXCLUSIVE, all-important features of Ric-wiL Systems. They stand out like a smokestack on a power house!

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Ric-wiL Base Drain insures a DRY ditch, which leading engineers say is absolutely necessary for efficiency.

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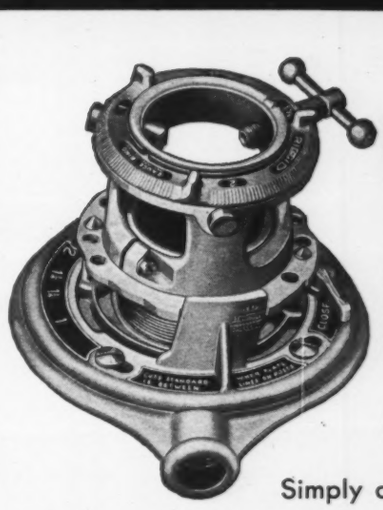
CONDUIT SYSTEMS FOR UNDERGROUND STEAM PIPES

NO MORE Changing Dies

This No. 65R RIDGID Die Stock threads 4 sizes of pipe (1", 1¼", 1½", 2") with 1 set of dies.



RIDGID No. 65R Ratchet threader. Made also as No. 85R with 2 handles. No. 65 plain die has 2 handles.

•

RIDGID No. 65R, back view.

Simply change the setting post on this RIDGID No. 65R and go ahead—threads 1", 1¼", 1½", 2" pipe.

True accurate threads, all variations.

New type self-contained work-holder: turn arrow on knurled gauge ring to pipe size, put on pipe, tighten one screw.

Direct pull over dies. Plenty of chip room. Feet to stand it up.

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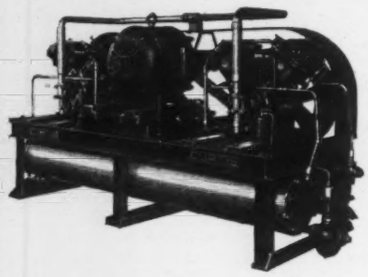
AGE ISN'T ALL

. . . but Experience is mighty important



BEHIND every Curtis condensing unit stands thirteen years of continuous development, 43 years of experience in making fine compressors, and an engineering and manufacturing background that dates back 83 years to 1854.

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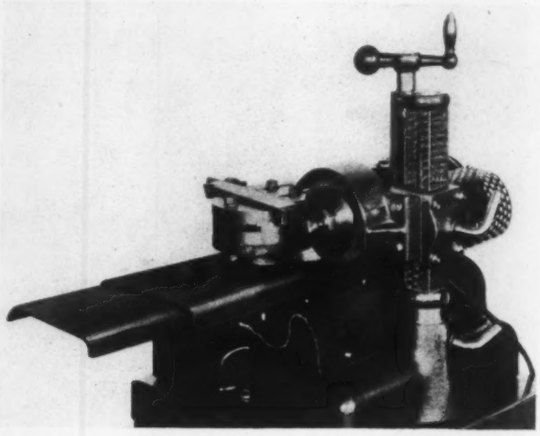
perfect grind on cutting edge and lead, according to the manufacturer. A special thin type grinding wheel makes it easy to grind out broken teeth. The grinder is small and compact and is powered by a universal motor which runs from an ordinary electric light socket.

Standard equipment consists of one set of special fixtures and



wheels for grinding any one type of chaser; universal motor and dressing stick for grinding wheels. A welded steel stand with built-in shelf for extra fixtures can be furnished as an extra.—Oster Mfg. Co., 2057 E. 61st Pl., Cleveland, Ohio.

Novel Conveyor is Moving Pipe Line

No. 1175—A novel development in the conveying of solids and liquids is in effect a "moving pipe line" of rubber. The conveyor receives the material to be conveyed from hoppers which may be located at one or more points along its line of travel and conveys it vertically, horizontally or in any other direction to any one or more predetermined discharge points, the flexible rubber tube moving around pulleys.

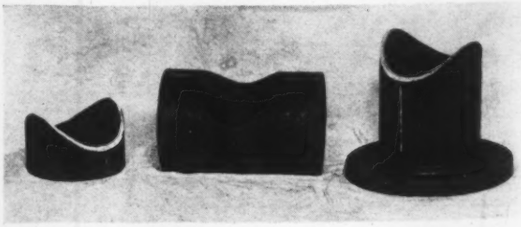
The moving rubber tube is split into two halves throughout its length so that it can be pulled apart at any point to receive or discharge material. The halves fit together by means of double tongues and grooves which prevent leakage of material. When the halves are together the tube is twisted, in the manner of a rope, which compresses them and makes a tight seal. One of the halves is fitted with disc-like partitions or flights which serve to pick up a full load when passing through a feed hopper, and form individual compartments to prevent slipping and packing of the material on vertical lifts.

In handling liquids, these partitions are compressed so firmly against the other half when the tube is twisted that each compartment carries its own load independent of the others. Thus, the internal pressure at the bottom of a 1000 ft lift is no more than it is at the top. The conveyor is thus useful as a "pump" for removing water from mines and quarries.

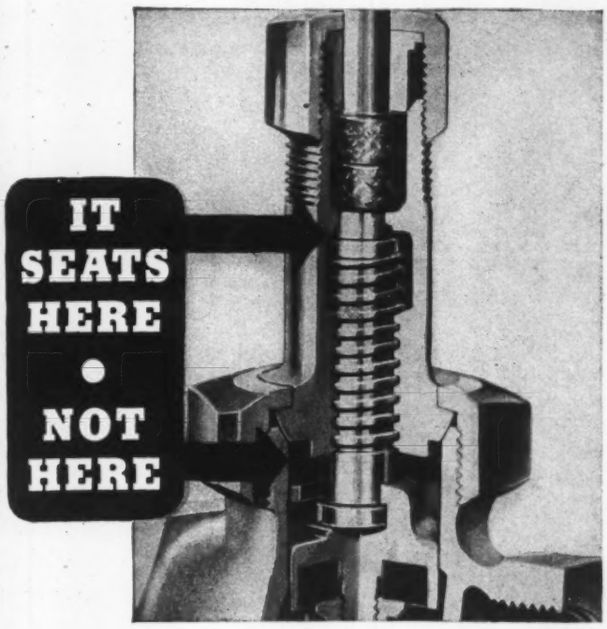
Applications include conveying coal, foodstuffs—particularly sticky material such as dried fruits—handling wet mixtures such as concrete and mortar, chemicals, crushed lime, etc.—Johns Conveyor Corp., 605 Broad St., Newark, N. J.

Machine Prepares Pipe for Welding

No. 1176**—Improved pipe fitting machine for cutting and preparing pipe for fabrication into welded tees, miter elbows,



No Danger of Burning Hands When Packing Under Pressure



No scalding steam or hot liquid can possibly escape when repacking the stuffing box of a Fairbanks Renewable Valve under pressure.

A tight joint is always certain because the shoulder on the stem which engages the seat in the bonnet is ABOVE the threads on the stem. No sediment or foreign matter can reach this point and prevent a tight closing.

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Illustration shows an ANEMOSTAT Draftless Air Diffuser

installation in one of the popular Kayser Stores in New York City. (Engrs. Messrs. Connolly & Schmidt, New York. Architect, Edward I. Shire, Esq., New York.) Kayser's customers shop in perfect comfort in this pleasantly cooled store without experiencing the harmful and unpleasant sensation of draft.

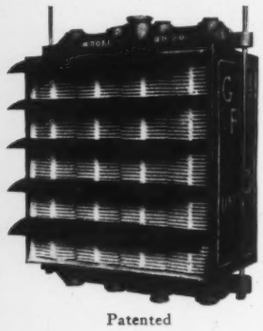
Data for this installation:

Total length of store	46'
Length of store in rear	32', 2"
Width of store in front	14'
Width of store in rear	10', 1"
Height of ceiling	9', 11"
Each ANEMOSTAT distributes	500 cfm
Total number of ANEMOSTATS	3

"No Air Conditioning System is better than its Air Distribution."

ANEMOSTAT CORP. of AMERICA
551-FIFTH AVENUE, NEW YORK CITY.

A UNIT HEATER *THAT WILL NOT* FALL APART *from* CORROSION



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All cast aluminum heating sections that positively eliminate electrolysis that produces corrosion, in the Grid Unit Heater there are no dissimilar metals in contact with each other and steam. Neither are there soldered, pressed, or rolled joints, or unions—and the fewest connections possible. There is no maintenance expense with the GRID. In 8 heating seasons there have been no failures due to leaks or breakdowns. We'll gladly send you complete information.

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GRID UNIT HEATER

headers, etc., and for bevelling plain end pipe for butt welds, is available in three capacities for 1½ to 12 in., 2 to 18 in., and 3 to 24 in. pipe. A quick change gear box provides 18 different cutting speeds. Cutting speed ranges from 10 to 14 in. per minute, depending upon temperature and thickness of pipe wall.

No templates or patterns are needed, the required template for the cut being generated in the machine itself. According to the maker, the cuts are smooth, clean and free of scale and oxide. The heat is localized, it is stated, the correct and constant cutting speed practically eliminating warping and distorting of the pipe. Cuts are made to a center punch mark or center line scribed before the cut is made; a centering tool is provided.

Referring to the illustration, the hole in the header is a straight unbevelled cut, and the neck or branch rests on the outside of the header like a saddle. A gradual change in the bevel on the neck provides at all points an included angle ample for perfect penetration to the root of the weld, according to the manufacturer.—Douglass Pipe Machine Co., St. Joseph, Mich.

Schools and Study Courses

Youth Administration Gives Job Information on Air Conditioning

Air conditioning is attracting many boys and young men over 16 years of age to job information classes conducted by the National Youth Administration, according to a report received from the NYA.

When William J. Campbell, state director of the NYA for Illinois, called into being this phase of an extensive vocational program to aid boys and girls to find employment in private industry, air conditioning was one of the first subjects on which he wished information given. Already nearly 8,000 boys and young men between the ages of 16 and 25 have attended classes on air conditioning at two-score centers in Chicago and downstate.

Teachers at the classes explain that the industry is divided into four major phases: (1) Designing and manufacturing, (2) Sales, (3) Installation, (4) Operation and Maintenance. It is pointed out that each of these activities has its own trained workers, and that no one of them can be said to be more important than any other.

The problem then is to break down these phases into individual jobs for youth enlightenment; to tell the duties of each job, and state what qualifications, either in experience or academic background, are necessary. Data as to the designing engineer, sales engineer, construction engineer, installer, stationary engineer, and maintenance and repair man are given. The idea is that in a diversified group of young men over 16 years of age, what appeals to one does not appeal to another, nor are all of the same educational standard.

The National Youth Administration was created in 1935. To provide information on industry, a research staff of college trained men and women was put to work gathering, sorting and weighing facts and figures. This information was written into monographs for the benefit of the teacher-lecturers, later to be passed to the youths themselves. In Chicago alone since last March, 4651 job information classes were held up to the end of December. A total of more than 28,260 boys and 23,632 girls attended these classes. In downstate Illinois, 84 classes were held in Marietta, 572 in Springfield, 276 in Rockford, 4 in Sparta, and 60 in Decatur. Total attendance of these classes reached 13,559.

INDUSTRY LOOKS TO RANDALL FOR BEARINGS

CHICAGO'S GREAT BRIDGES are equipped with RANDALL BEARINGS

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In air conditioning, 75% of the industry comes to Randall for pillow blocks to get quiet . . . dependable . . . trouble-free operation.

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there's a Best in EVERYTHING

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Blowers of every size and type made to exactly answer every purpose—utility blowers, light duty, heavy duty, single and double inlet blowers—all expertly designed and ruggedly constructed to deliver at all times the maximum of satisfactory service.

No matter what air conditioning equipment you may need—blowers, ventilators, propeller fans, air washers, unit coolers, unit heaters, blast heat coils, exhausters, humidifiers, automatic shutters—you would profit by becoming familiar with the National line before making any purchase. Send for bulletins.

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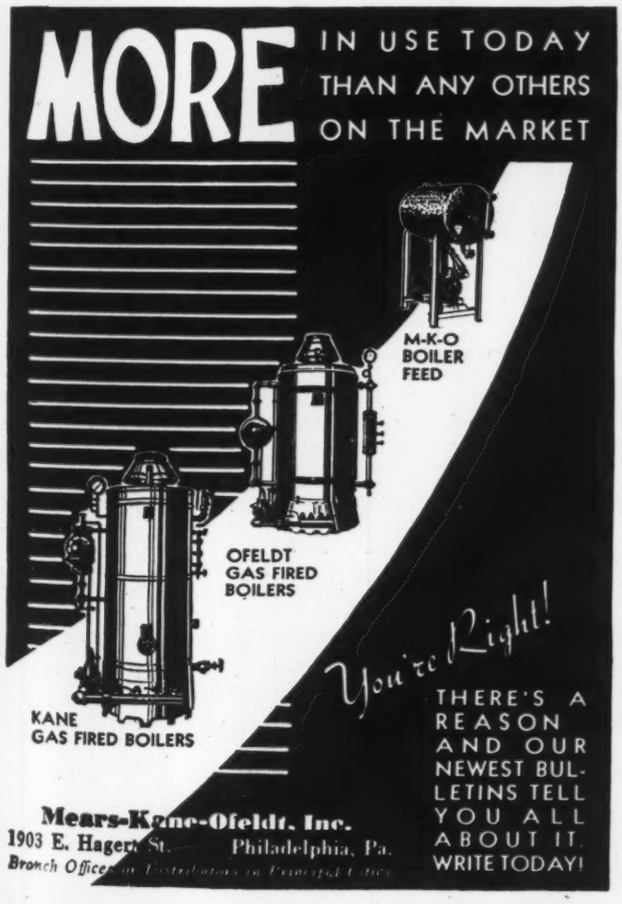

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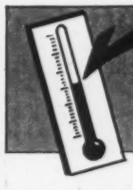
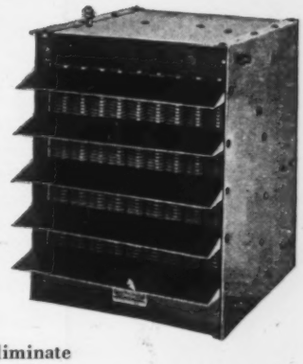
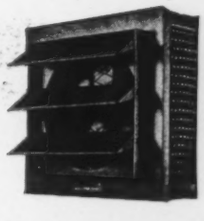


check THE TEMPERATURE OF YOUR PLANT NOW!

Is it a constant, efficient working temperature throughout? Are there "cold spots" in your plant that lower the productiveness of your workers? Do you have to run your entire heating system when one or two departments work overtime? Are you without *surplus* heat for sudden cold snaps? Any and all of these things can add greatly to your overhead. Eliminate them *now!* Install CHROMALOX Electric Unit Heaters.



ABOVE—Type UAB Chromalox equipped Unit Heater, built in capacities from 5 Kw. (17,060 B.t.u.) to 40 Kw (136,480 B.t.u.)



BELOW — Type HF Chromalox equipped Unit Heater available in six sizes: 1.5 Kw to 4.5 Kw.

EDWIN L. WIEGAND COMPANY
7610 Thomas Blvd. Pittsburgh, Pa.

Home Study Course in Air Conditioning Revised

The university extension division of Rutgers University, New Brunswick, N. J., has announced that its home study course in air conditioning has been completely revised and enlarged. Revision was deemed necessary to keep abreast with the newer applications of air conditioning, as well as with changes in equipment.

The course includes sections on heat and heat transfer; humidity; heating; the psychrometric chart; cooling; heating, cooling, humidifying and dehumidifying equipment; refrigeration; filters; gas-consuming air conditioning equipment; fans and air distribution; control apparatus and applications; and developments and trends. The fee, including text material and correction service, is $24.

Many Air Conditioning Classes Announced

With the beginning of the second half of the school year, a number of air conditioning classes have been announced.

Alfred L. Jaros is presenting a course in air conditioning at the School of Architecture and Allied Arts, New York University, 1071 Sixth Ave., New York City. The class meets on Wednesdays (8:05-9:50 p. m.), the first meeting being scheduled for February 3, and the fee is $25.

At Columbia University School of Architecture, New York City, air conditioning is the subject of a general course directed by R. W. Waterfill. Effort will be made to present material to both the technically and non-technically trained student, and practical use of the psychrometric chart and the handling of heat and air will be emphasized. The class is to meet Mondays and Thursdays at 8:25 p. m.

In Chicago, evening classes in elementary and advanced air conditioning under the direction of William Bodinus and Julius Wolf started February 1 at Lewis Institute. The courses require two evenings a week for a term of fifteen weeks. At Armour Institute of Technology, Chicago, a course in industrial air conditioning has been announced, meeting Mondays and Thursdays at 7:30 p. m.; the instructor is Professor H. L. Nachman. An advanced course, the student is assigned a specific industrial plant and required to make a complete analysis of an air conditioning system to meet its particular needs.

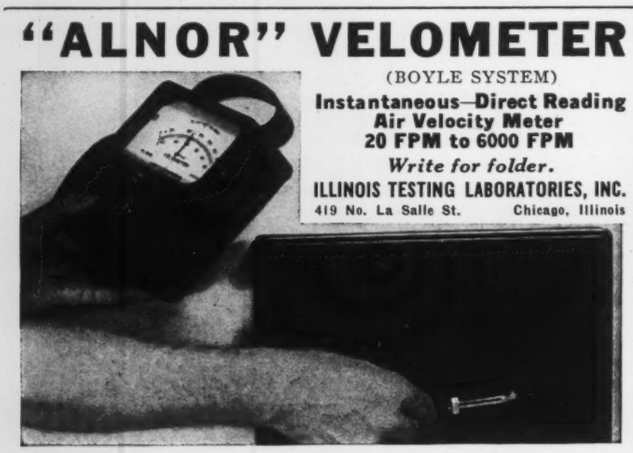
Book Reviews

Lessons in Arc Welding

"Lessons in Arc Welding," published by the Lincoln Electric Co., 12818 Coit Rd., Cleveland, Ohio. Mimeographed, 130 pp., 8x10½ in., loose-leaf binding. Price, 50c in U. S.; 75c elsewhere.

It is the object of the 44 lessons presented in this book to give, in concise manner, certain fundamental facts of welding, the knowledge of which will enable the operator to use the arc welding process successfully and economically.

The lessons, which are based on the course conducted by the publisher in its plant welding school for nearly 20 years, cover the arc welding machine, its operation and control; the shielded arc and its uses; striking the arc and running horizontal bead; running a bead not less than 12 in. long; weaving the electrode; effect of arc length, current and speed on bead; effect of polarity on bead; types of electrodes; padding and building up plates; building up shafts; butt, lap, tee, vertical, and horizontal welds; overhead welding; expansion and contraction; penetration and cutting; welding of mild steel, light gauge steel, high tensile steels, cast iron, stainless steels; hard facing various metals; welding aluminum, bronze, brass, copper and 4-6 chrome steels. Welding with bare electrode is also covered to give the student complete training in all phases of welding. Several pages of examination questions are included.



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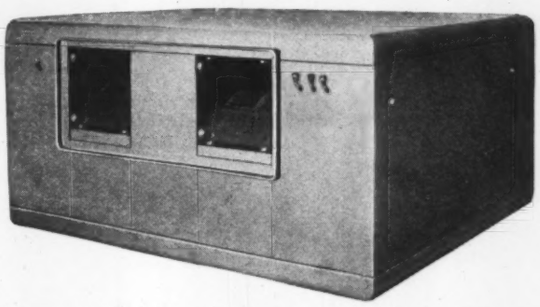

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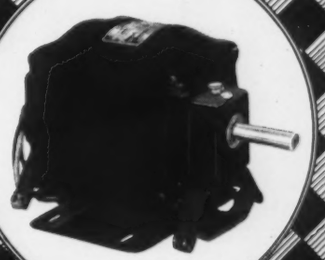

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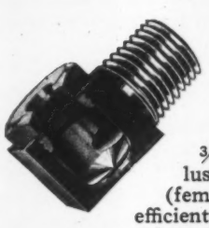

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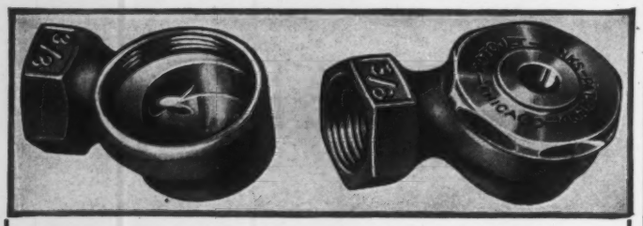

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Conventions and Expositions

Oil Burner Institute: Oil burner and air conditioning exposition and convention, March 15-19, Commercial Museum, Philadelphia, Pa.

International Association for Testing Materials: 2nd International Congress, April 19-24, London, England. Honorary Secretary, K. Headlam-Morley, 28 Victoria St., London, S.W.1.

Heating, Piping and Air Conditioning Contractors' National Association: Annual convention, May 17-19, Hotel Nicollet, Minneapolis, Minn. Secretary, Joseph C. Fitts, 1250 Sixth Ave., New York, N. Y.

Short Course in Coal Utilization: May 25-27, University of Illinois, Urbana, Ill. D. R. Mitchell, Department of Mining and Metallurgical Engineering, 212 Transportation Bldg., Urbana, Ill.

American Society of Refrigerating Engineers: Spring meeting, May 25-27, French Lick Springs, Ind. Secretary, David L. Fiske, 37 W. 39th St., New York, N. Y.

Smoke Prevention Association: Annual convention, June 1-4, Hotel Pennsylvania, New York, N. Y. Secretary, Frank A. Chambers, 139 N. Clark St., Chicago, Ill. Fuel burning and air pollution exhibition to be held in conjunction with convention in ballroom of Hotel Pennsylvania, May 31-June 5.

American Society for Testing Materials: Annual meeting and exhibit of testing apparatus, June 28-July 2, The Waldorf-Astoria, New York, N. Y. Headquarters Office, 260 S. Broad St., Philadelphia, Pa.

Universal Craftsmen Council of Engineers of the World: Power show and mechanical exposition, August 3-7, Hotel Stevens, Chicago, Ill. General Chairman, W. T. Walters, 7965 Phillips Ave., Chicago, Ill.

Recent Trade Literature

For your convenience in obtaining copies of bulletins, see coupon on page 134.

No. 2263. AIR CONDITIONING COILS: Fedders Mfg. Co., Inc., 57 Tonawanda St., Buffalo, N. Y. 46 p. bulletin of technical and engineering data on water type air conditioning coils for cooling and dehumidifying of air, believed to be one of the most complete bulletins on the subject published. Design features of this manufacturer's coils are described and illustrated briefly, the greater part of the bulletin comprising rating tables based on a year of test work, and giving Btu per hr per sq in. frontal—latent, sensible and total heat for the coils. Information on the basis and use of the tables is presented, and other pertinent information is included. Instructions for solving various types of problems and typical examples are appended.

No. 2264. AIR FILTERS: Emmett F. Annis, 1515 Gardena Ave., Glendale, Calif. (a) Looseleaf folder describing the design, and applications of dry type air filters, and including reports of results achieved on several installations. (b) Bulletin on air filters for air compressors and internal combustion engines with data on applications and features.

No. 2265. BOILERS: American Radiator Co., 40 W. 40th St., New York, N. Y. (a) 8 p. bulletin of general information on "Ideal" automatic coal burning boilers, covering their selection and application. Identification, rating, selecting stoker boilers, and features of these boilers are covered. (b) 6 p. bulletin giving ratings and other data for handy reference and quick selection of these boilers.

No. 2266. CONDENSATION RETURN UNITS: The Deming Co., 14 Aetna St., Salem, Ohio. 8 p. bulletin on electric

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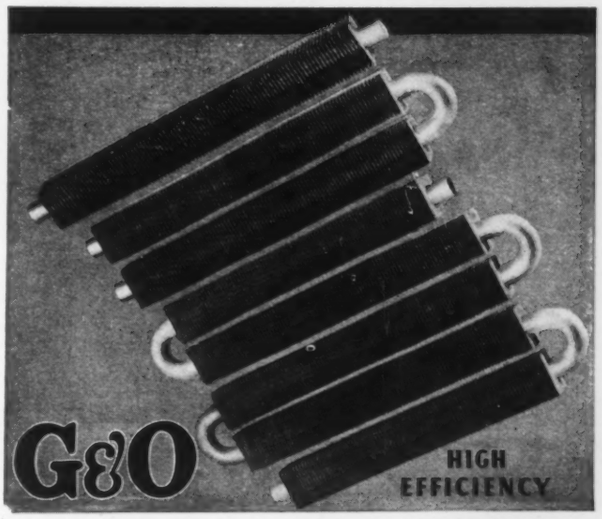

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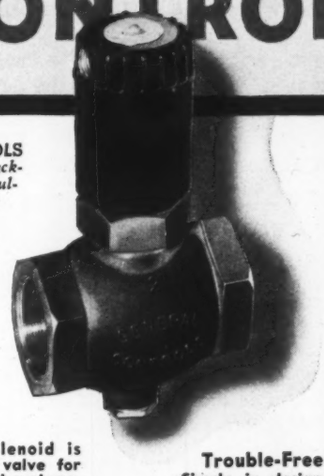

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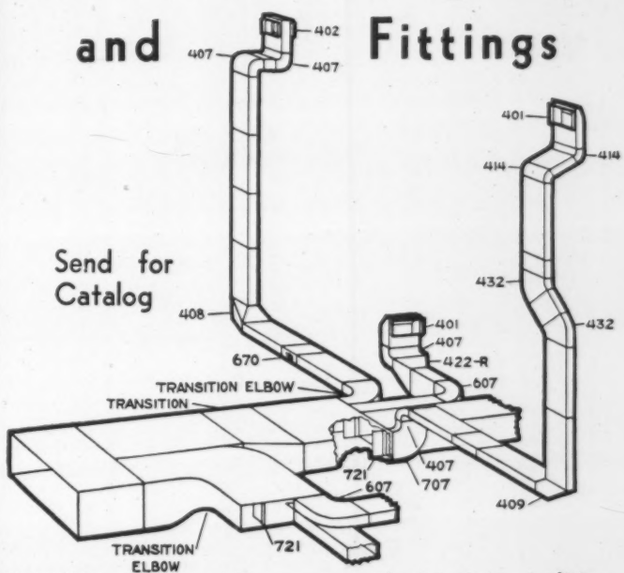

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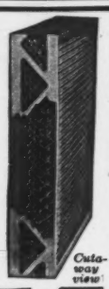

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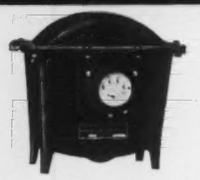

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No. 2267. DRIVES: J. E. Rhoads & Sons, 11th & B. & O. R. R., Wilmington, Del. 4 p. pamphlet stating this company's opinions on the relative advantages of V-belt and flat belt drives.

No. 2268. HUMIDITY CONTROL: The Foxboro Co., 106 Neponset Ave., Foxboro, Mass. 40 p. bulletin entitled "Wet and Dry," discussing instruments and application methods for humidity control in a wide range of industrial drying and processing operations. The instruments reviewed include direct reading relative humidity recorders, recorder-controllers, and indicating controllers; wet and dry bulb recorders, recorder controllers, indicating controllers, non-recording controllers, and time-humidity recorder-controllers; and auxiliary equipment such as water boxes, valves, dampers, charts, etc.

No. 2269. MOTORS: Century Electric Co., 1806 Pine St., St. Louis, Mo. 8 p. bulletin on single phase, brush lifting, repulsion start induction motors, ⅛ to 40 hp, describing and illustrating features of design.

No. 2270. PIPE COILS: Rempe Co., 340 N. Sacramento Blvd., Chicago, Ill., 48 p. catalog of iron pipe coils for ice and refrigerating machines, cold storage houses, chemical works, blast furnaces, soap factories, feedwater heaters, and other purposes. Photographs and drawings of the various types of coils are shown.

No. 2271. PIPE MACHINES AND TOOLS: The Oster Mfg. Co., 2057 E. 61st Pl., Cleveland, O. Looseleaf catalog on pipe machines, including stocks and dies, portable pipe machines, power pipe machines, pipe welding clamps, pipe welding assembly benches, gas cutting machines for pipe intersections, and cutting oil for pipe threading work.

No. 2272. PROCESS CONTROL: The Bristol Co., Platts Bridge, Waterbury, Conn. 18 p. bulletin on this company's system of coordinated process control for completely automatic control of various plant processes. The method and its advantages are described, and a number of typical installations are briefly described and illustrated.

No. 2273. PULVERIZED COAL SYSTEMS: The Babcock & Wilcox Co., 85 Liberty St., New York, N, Y. (a) Bulletin on direct firing pulverized coal systems for power boilers and other applications. (b) 32 p. bulletin presenting tables of grindabilities and analyses of U. S. and Canadian coals of interest to those concerned with the burning of pulverized coal.

No. 2274. PUMPS: Economy Pumping Machinery Co., Inc., 3431 W. 48th Pl., Chicago, Ill. 256 p. "pump data" handbook, pocket size, made up of two parts—the first dealing with the various classes of pumps, listing recommended sizes by the desired capacity and pumping head, tabulating efficiency, required hp, pump cost, motor and control cost, and featuring a compre-

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hensive application or use index arranged for easy reference. The second part, on engineering data, gives detailed information on the hydraulics of pumping, piping, and related technical information and tables.

No. 2275. PUMPS: Goulds Pumps, Inc., Fall St., Seneca Falls, N. Y. 112 p. dealer catalog covering a complete range of water systems, hand pumps, miscellaneous power pumps and accessories. Data on computing water requirements, friction loss in piping, head and pressure equivalents, etc., are included.

No. 2276. PILLOW BLOCKS: Randall Graphite Products Corp., 609 W. Lake St,, Chicago, Ill. 24 p. booklet on self-aligning and self-lubricating pillow blocks, giving specifications and installation data on six types. Features are described and detailed specifications are given.

No. 2277. REGISTERS: Independent Register Co., 3747 E. 93rd St., Cleveland, Ohio. 20 p. catalog of registers, ventilators, and grilles of various types, giving descriptions of features, tabulated application data, and list prices.

No. 2278. THERMAL OVERLOAD SWITCH: General Electric Co., 1 River Rd., Schenectady, N. Y. Data sheet on new completely self-contained thermal overload switch for fractional hp motors, operating on line current and arranged for convenient mounting on conduit or terminal box of the motor.

No. 2279. VALVES: Edward Valve & Mfg. Co., Inc., 1200 W. 145th St., East Chicago, Ind. New discount sheet on cast steel and drop forged steel valves.

No. 2280. WELDING: Linde Air Products Co., Unit of Union Carbide & Carbon Corp., 30 E. 42nd St., New York, N. Y. 32 p. booklet on "Lindewelding" cross country pipe lines, discussing economy and rapidity of this method of construction, joint design, quality and strength of welds, and simplicity of field operations, and giving information on many other topics. A list of oxy-acetylene welded lines laid since 1917 is included, and many construction pictures are reproduced.

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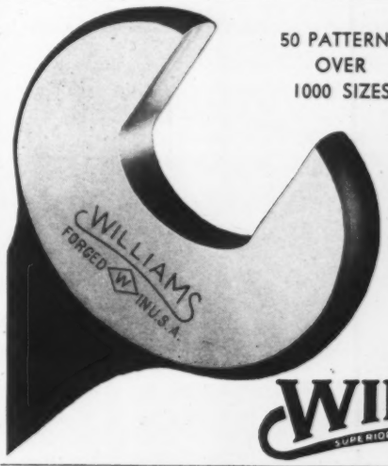

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